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NEW CHAPTERS IN THE WARFARE OF SCIENCE.

XIX.—FROM CREATION TO EVOLUTION.

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PART III.

THEOLOGICAL AND SCIENTIFIC THEORIES OF AN EVOLUTION IN ANIMATED NATURE.

WE have seen, thus far, how there came into the thinking of mankind upon the visible universe and its inhabitants the idea of a creation virtually instantaneous and complete, and the conception of a Creator in human form with human attributes, who spoke matter into existence literally by the exercise of His throat and lips, and who shaped and placed it with His hands and fingers.

We have seen that this view came from far; that it existed in the Chaldæo-Babylonian civilization and probably in others of the earliest date known to us; that its main features passed thence into the sacred books of the Hebrews and then into the early Christian Church, by whose theologians it was developed through the middle ages and maintained during the modern period.

But, while this idea was thus developed by a succession of noble and thoughtful men through thousands of years, another conception—to all appearance equally ancient—was developed, sometimes in antagonism to it, sometimes mingled with it: the conception of all living beings as wholly or in part the result of a growth process—of an evolution.

This idea, in various forms, became a powerful factor in nearly all the greater ancient theologies and philosophies. For very

widespread among the early peoples who attained to much thinking power was a conception that the universe arose from a watery chaos, and that its inhabitants were produced by sea and on land in obedience to a divine fiat.

This is clearly seen in the same records of Chaldæo-Babylonian thought deciphered in these latter years, to which reference has been made in previous chapters. In these we have a watery chaos which, under divine action, brings forth the earth and its inhabitants; first the sea animals and then the land animals, the latter being separated into three kinds, substantially as recorded afterward in the Hebrew accounts. At the various stages in the work the Chaldæan Creator pronounces it "beautiful," just as the Hebrew Creator in our own later account pronounces it "good."

In both accounts there is placed over the whole creation a solid, concave firmament; in both, light is created first and the heavenly bodies are afterward placed "for signs and for seasons"; in both the number seven is especially sacred, giving rise to a sacred division of time and to much else. It may be added that, with many other features in the Hebrew legends evidently drawn from the Chaldæan, the account of the creation in each is followed by a legend regarding "the fall of man" and a deluge, many details of which clearly passed in slightly modified form from the Chaldæan into the Hebrew accounts.

It would have been a miracle indeed if these primitive conceptions, wrought out with so much poetic vigor in that earlier civilization on the Tigris and Euphrates, had failed to influence the Hebrews, who, during the most plastic periods of their development, were under the tutelage of their Chaldæan neighbors. Since the researches of Layard, George Smith, Oppert, Schrader, Sayce, and their compeers, there is no longer a reasonable doubt that this ancient view of the world, elaborated if not originated in that earlier civilization, came thence as a legacy to the Hebrews, who wrought it in a somewhat disjointed shape and in a form mainly monotheistic into the poetic whole which forms one of the most precious treasures of ancient thought preserved in the book of Genesis.

Thus it was that, while the idea of a simple material creation literally by the voice, hands, and fingers of the Creator became, as we have already seen, the starting-point of a powerful stream of theological thought, and while this stream was swollen from age to age by contributions from the fathers, doctors, and learned divines of the Church, Catholic and Protestant, there was poured into it this lesser current, always discernible and at times clearly separated from it—a current of belief in a process of evolution.

The Rev. Prof. Sayce, of Oxford, than whom no English-speaking scholar carries more weight in a matter of this kind, has

recently declared his belief that the Chaldæo-Babylonian theory was the undoubted source of the similar theory propounded by the Ionic philosopher Anaximander, in the sixth century, the Greek thinkers deriving this view from the Babylonians through the Phœnicians; and he also allows that from the same source its main features were adopted into both the accounts given in the first of our sacred books, and in this general view the most eminent Christian Assyriologists concur.

It is true that each of these sacred accounts of ours contradicted the other. In that part of the first or Elohistic account given in the first chapter of Genesis the *waters* bring forth fishes, marine animals, and birds (Genesis, i, 20); but in that part of the second or Jehovistic account given in the second chapter of Genesis both the land animals and birds are declared to have been created not out of the water, but "*out of the ground*" (Genesis, ii, 19).

The dialectic skill of the fathers was easily equal to explaining away this contradiction between these two legends as regards the origin of birds; but the old current of thought, strengthened by both these accounts, arrested their attention, and, passing through the minds of a succession of the greatest men of the Church, influenced theological opinion deeply, if not widely, for ages in favor of an evolution theory.

This ancient idea that the animals and man were produced by lifeless matter at the divine command "in the beginning" was afterward supplemented by the idea, strengthened doubtless by Aristotle, that some of the lesser animals, especially the insects, were produced by a sort of later evolution, being evoked after the original creation from various sources, but chiefly from matter in a state of decay.

As typical examples of this thought we may note the view taken by St. Basil the Great in the fourth century. Discussing the work of creation, he declares that, at the command of God, "the waters were gifted with productive power"; "from slime and muddy places frogs, flies, and gnats came into being"; and he finally declares that the same voice which gave this energy and quality of productiveness to earth and water shall be similarly efficacious until the end of the world.

This idea of the great father of the Eastern Church took even stronger hold on the great father of the Western Church. For St. Augustine, so fettered usually by the letter of the sacred text, broke from his own famous doctrine as to the acceptance of Scripture and spurned the generally received belief of a creative process like that by which a toymaker brings into existence a box of playthings. In his great treatise on Genesis he says: "To suppose that God formed man from the dust with bodily hands is

very childish. . . . God neither formed man with bodily hands nor did He breathe upon him with throat and lips."

Augustine then suggests the adoption of the old emanation or evolution theory, adding that "certain very small animals may not have been created on the fifth and sixth days, but may have originated later from putrefying matter," and argues that, even if this be so, God is still their creator.

He dwells upon such a potential creation as involved in the actual creation, and speaks of animals "whose numbers the after-time unfolded."

In his great treatise on the Trinity—the work to which he devoted the best thirty years of his life—we find the full growth of this opinion. He develops at length the view that in the creation of living beings there was something like a growth—that God is the ultimate author, but works through secondary causes, and finally argues that certain substances are endowed by God with the power of producing certain classes of plants and animals.*

This idea of a development apart from the original creation and by secondary causes was helped in its growth by a theological exigency. More and more as the organic world was observed, no matter how imperfectly, the vast multitude of petty animals, winged creatures, and "creeping things" was instinctively felt to be a strain upon the sacred narrative. More and more it became difficult to reconcile the dignity of the Almighty with his work in bringing each of these creatures before Adam to be named; or to reconcile the human limitations of Adam with his work in

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* For the Chaldæan view of creation, see George Smith, Chaldæan Account of Genesis, New York, 1876, pp. 14, 15, and 64–86; also Lukas, as above; also Sayce, Religion of the Ancient Babylonians, Hibbert Lectures for 1887, pp. 371 and elsewhere; as to the fall of man, Tower of Babel, sacredness of the number seven, etc., see also Delitzsch, appendix to the German translation of Smith, pp. 305 *et seq.*; as to the almost exact adoption of the Chaldæan legends into the Hebrew sacred account, see all these, as also Schrader, Die Keilinschriften und das Alte Testament, Giessen, 1883, early chapters; also article Babylonia in the Encyclopædia Britannica; as to the similar approval of creation by the Creator in both accounts, see George Smith, p. 73; as to the migration of the Babylonian legends to the Hebrews, see Schrader, Whitehouse's translation, pp. 44, 45; as to the Chaldæan belief in a solid firmament, while Schrader in 1883 thought it not proved, Jensen in 1890 has found it clearly expressed—see his Kosmologie der Babylonier, pp. 9 *et seq.*, also pp. 304–306, and elsewhere. Dr. Lukas in 1893 also fully accepts this view of a Chaldæan record of a "firmament"; see Kosmologie, pp. 43, etc.

For the seven-day week among Chaldæans and rest on the seventh day, and the proof that even the name "Sabbath" is of Chaldæan origin, see Delitzsch, Beigaben zu Smith's Chald. Genesis, pp. 300 and 306; also Schrader; for St. Basil, see Hexæmeron and Homilies vii–ix; but, for the steadfastness of Basil's view in regard to the immutability of species, see a Catholic writer on Evolution and Faith in the Dublin Review for July, 1871, p. 13; for citations of St. Augustine on Genesis, see the De Genesi, lib. ii, cap. 14, in Migne, xxxiv, 188; lib. v, cap. 5 and cap. 23; and lib. vii, cap. 1; for the citations from his work on the Trinity, see his De Trinitate, lib. iii, cap. 8 and 9, in Migne, xlii, 877, 878.

naming "every living creature"; or to reconcile the dimensions of Noah's ark with the space required for preserving all of them, and the food of all sorts necessary for their sustenance, whether they were admitted by twos, as stated in one scriptural account, or by sevens, as stated in the other.

This latter subject gave especial trouble. Origen had dealt with it by suggesting that the cubit was six times greater than had been supposed. Bede explained Noah's ability to complete so large a vessel as the ark by supposing that he worked upon it during a hundred years; and, as to the provision of food taken into it, he declared that there was no need of a supply for more than one day, since God could throw the animals into a deep sleep or otherwise miraculously make one day's supply sufficient; he also lessened the strain on faith still more by diminishing the number of animals taken into the ark, supporting his view upon Augustine's theory of the later development of insects out of carrion.

Doubtless this theological necessity was among the main reasons which caused the theory—supported by St. Basil and St. Augustine—to be incorporated in the seventh century by St. Isidore of Seville into his great encyclopedic work which gave materials for thought on God and Nature to so many generations. He familiarized the theological world still further with the doctrine of secondary creation, giving such examples of it as that "bees are generated from decomposed veal, beetles from horseflesh, grasshoppers from mules, scorpions from crabs," and, in order to give still stronger force to the idea of such transformations, he dwells on the biblical account of Nebuchadnezzar, which appears to have taken strong hold upon mediæval thought in science, and declares that other human beings had been changed into animals, especially into swine, wolves, and owls.

This doctrine of after-creations went on gathering strength until, in the twelfth century, Peter Lombard, in his theological summary "The Sentences," so powerful in molding the thought of the Church, emphasizes the distinction between animals which spring from carrion and those which are created from earth and water; the former he holds to have been created "potentially," the latter "actually."

In the century following, this idea was taken up by St. Thomas Aquinas and virtually received from him its final form. In the "Summa," which remains the greatest work of mediæval thought, he accepts the idea that certain animals spring from the decaying bodies of plants and animals, and declares that they are produced by the creative word of God either actually or virtually. He develops this view by saying, "Nothing was made by God, after the six days of creation, absolutely new, but it was in some sense

included in the work of the six days"; and that "even new species, if any appear, have existed before in certain native properties, just as animals are produced from putrefaction."

The distinction thus developed between creation "causally" or "potentially," and "materially" or "formally," was made much of by commentators afterward. Cornelius a Lapide spread it by saying that certain animals were created not "absolutely," but only "derivatively," and this thought was still further developed three centuries later by Augustinus Eugubinus, who tells us that, after the first creative energy had called forth land and water, light was made by the Almighty, the instrument of all future creation, and that the light called everything into existence.

All this "science falsely so called," so sedulously developed by the great minds of the Church, and yet so futile that we might almost suppose that the great apostle, in a glow of prophetic vision, had foreseen it in his famous condemnation, seems at this distance very harmless indeed; yet, to many guardians of the "sacred deposit of doctrine" in the Church, even so slight a departure from the main current of thought seemed dangerous. It appeared to them like pressing the doctrine of secondary causes to a perilous extent; and about the beginning of the seventeenth century we have the eminent Spanish Jesuit and theologian Suarez denouncing it, and declaring St. Augustine a heretic for his share in setting it in motion.

But there was little danger to the older idea just then; the main theological tendency was so strong that the world kept on as of old; biblical theology continued to spin its own webs out of its own bowels, and all the lesser theological flies continued to be entangled in them; yet here and there stronger thinkers broke loose from this entanglement and helped somewhat to disentangle others.*

But while within the Church the current of evolutionary thought was almost lost to sight, it continued in its clearer form,

* For Bede's view of the ark and the origin of insects, see his Hexæmeron, i and ii; for Isidore, see the Etymologiæ, xi, 4, and xiii, 22; for Peter Lombard, see Sent., lib. ii, dist. xv, 4 (in Migne, cxcii, 682); for St. Thomas Aquinas as to the laws of Nature, see Summa Theologica, i, Quæst. lxvii, art. iv; for his discussion on Avicenna's Theory of the origin of animals, see ibid., Quæst. lxxi, vol. i, pp. 1184 and 1185, of Migne's edit.; for his idea as to the word of God being the active producing principle, see ibid., i, Quæst. lxxi, art. i; for his remarks on species, see ibid., i, Quæst. lxxii, art. i; for his ideas on the necessity of the procreation of man, see ibid., i, Quæst. lxxii, art. i; for the origin of animals from putrefaction, see ibid., i, Quæst. lxxix, art. i, 3; for Cornelius a Lapide on the derivative creation of animals, see his In Genesim Comment., cap. i, cited by Mivart, Genesis of Species, p. 282; for a reference to Suarez's denunciation of the view of St. Augustine, see Huxley's Essays.

outside the Church, slowly to gain strength. On all sides, in every field, men were making discoveries which caused the general theological view to appear more and more inadequate.

In the first half of the seventeenth century Descartes seemed about to take for a time the leadership of human thought; his theories, however superseded now, gave a great impulse to investigation then. His genius in promoting an evolution doctrine as regarded the mechanical formation of the solar system was great, and his mode of thought strengthened the current of evolutionary doctrine generally; but his constant dread of persecution, both from Catholics and Protestants, led him steadily to veil his thoughts and even to suppress them. He had watched the Galileo struggle in all its stages; he had seen his own books condemned by university after university under the direction of theologians, and placed upon the index of prohibited books. Although he gave new and striking arguments to prove the existence of God, and humbled himself before the Jesuits, he was condemned by Catholics and Protestants alike; since Roger Bacon, perhaps, no great thinker had been so completely abased by theological oppression.

Near the close of the same century another great thinker, Leibnitz, though not propounding any full doctrine on evolution, gave it an impulse by suggesting a view contrary to the sacrosanct belief in the immutability of species—that is, to the pious doctrine that every species in the animal kingdom now exists as it left the hands of the Creator, the naming process by Adam, and the door of Noah's ark.

His punishment at the hands of the Church came a few years later, when, in 1712, the Jesuits defeated his attempt to found an Academy of Science at Vienna; the imperial authorities covered him with honors, but the priests—ruling in the confessionals and pulpits—would not allow him the privilege of aiding his fellowmen to ascertain God's truths revealed in Nature.

A few years after Leibnitz's death came in France a thinker in natural science of much less influence, but who made a decided step forward.

Early in the eighteenth century Benoist de Maillet, a man of the world, but a wide observer and close thinker upon Nature, began meditating especially upon the origin of animal forms, and was led into the idea of the transformation of species and so into a theory of evolution, which in some important respects anticipated modern ideas. He definitely conceived the production of existing species by the modification of their predecessors, and he plainly accepted one of the fundamental maxims of modern geology—that the structure of the globe must be studied in the light of the present course of Nature.

Unfortunately, De Maillet fell between two ranks of adversaries. On one side, the Church authorities denounced him as a freethinker; on the other, Voltaire ridiculed him as a devotee. Feeling that his greatest danger was from the orthodox theologians, De Maillet endeavored to protect himself by disguising his name in the title of his book, and by so wording its preface and dedication that, if persecuted, he could declare it a mere sport of fancy; he therefore announced it as the reverie of a Hindu sage imparted to a Christian missionary. But this strategy availed nothing; he had allowed his Hindu sage to suggest that the days of creation named in Genesis might be long periods of time, and this, with other ideas of equally fearful import, was fatal. Though the book was in type in 1735, it was not published till 1748—three years after his death.

On the other hand, the heterodox theology of Voltaire was also aroused; and, as De Maillet had seen in the presence of fossils on high mountains a proof that these mountains were once below the sea, Voltaire recognized an argument for the deluge of Noah, and ridiculed the new thinker without mercy.

Hence it is that, between these two extremes of theology, De Maillet has received no recognition until very recently the greatest men of science in England and France have united in giving him his due. But his work was not lost, even in his own day; Robinet and Bonnet pushed forward victoriously on helpful lines.

In the second half of the eighteenth century a great barrier was thrown across this current—the authority of Linnæus. He was the most eminent naturalist of his time, a wide observer, a close thinker; but the atmosphere in which he lived and moved and had his being was saturated with biblical theology, and this permeated all his thinking.

He who visits the tomb of Linnæus to-day, entering the beautiful cathedral of Upsala by its southern porch, sees above it, wrought in stone, the Hebrew legend of creation. In a series of medallions the Almighty—in human form—accomplishes the work of each creative day. In due order he puts in place the solid firmament with the waters above it, the sun, moon, and stars within it, the beasts, birds, and plants below it, and finishes his task by taking man out of a little hillock of "the earth beneath," and woman out of man's side. Doubtless Linnæus, as he went to his devotions, often smiled at this childlike portrayal. Yet he was never able to break away from the idea it embodied. At times, in face of the difficulties which beset the orthodox theory, he ventured to favor some slight concessions; but what he might expect if he sanctioned the new view he learned to his cost: warnings came speedily both from the Catholic and Protestant sides.

At a time when the most eminent prelates of the older Church

were eulogizing debauched princes like Louis XV, and using the unspeakably vile casuistry of Suarez in the education of the priesthood as to the relations of men to women, the modesty of the papal authorities was so shocked by Linnæus's proofs of a sexual system in plants that for many years his writings were prohibited in the Papal States and in various other parts of Europe where clerical authority was strong enough to resist the new scientific current. Not until 1773 did one of the more broad-minded cardinals—Zelanda—succeed in gaining permission that Prof. Minasi should discuss the Linnæan system at Rome.

And Protestantism was quite as oppressive. In a letter to Eloius, Linnæus tells of the rebuke given to science by one of the great Lutheran prelates of Sweden, Bishop Svedberg. From various parts of Europe detailed statements had been sent to the Royal Academy of Science that water had been turned into blood, and well-meaning ecclesiastics had seen in this an indication of the wrath of God, certainly against the regions in which these miracles had occurred and possibly against the whole world. A miracle of this sort appearing in Sweden, Linnæus looked into it carefully and found that the reddening of the water was caused by dense masses of minute insects. News of this explanation having reached the bishop, he took the field against it; he denounced this scientific discovery as "a Satanic abyss" (*abyssum Satanæ*), and declared "The reddening of the water is not natural," and "when God allows such a miracle to take place Satan endeavors, and so do his ungodly, self-reliant, self-sufficient, and worldly tools, to make it signify nothing." In face of this onslaught Linnæus retreated; he tells his correspondent that "it is difficult to say anything in this matter," and shields himself under the statement "It is certainly a miracle that so many millions of creatures can be so suddenly propagated," and "it shows undoubtedly the all-wise power of the Infinite."

The great naturalist, now grown old and worn with labors for science, could no longer resist the contemporary theology; he settled into obedience to it, and continued to adhere to the doctrine that all existing species had been created by the Almighty "in the beginning," and that since "the beginning" no new species had appeared.

Yet even his great authority could not resist the swelling tide; more and more vast became the number of species, more and more incomprehensible under the old theory became the newly ascertained facts in geographical distribution, more and more it was felt that the universe and animated beings had come into existence by some process other than special creation, and the question was constantly pressing, "By what process?"

Throughout the whole of the eighteenth century one man was

at work on natural history who might have contributed much toward an answer to this question; this man was Buffon. His powers of research and thought were remarkable and his gift in presenting results of research and thought showed genius. He had caught the idea of an evolution in Nature and was likely to make a great advance with it; but he, too, was made to feel the power of theology.

While he gave pleasing descriptions of animals the Church petted him, but when he began to deduce truths of philosophical import the batteries of the Sorbonne were opened upon him; he was made to know that "the sacred deposit of truth committed to the Church" was, that "in the beginning God made the heavens and the earth"; and that "all things were made at the beginning of the world." For his simple statement of truths in natural science which are to-day truisms, he was dragged forth by the theological faculty, forced to recant publicly, and to print his recantation. In this he announced, "I abandon everything in my book respecting the formation of the earth, and generally all which may be contrary to the narrative of Moses." *

But all this triumph of the Chaldæo-Babylonian creation legends which the Church had inherited availed but little.

About the end of the eighteenth century fruitful suggestions and even clear presentations of this or that part of a large evolutionary doctrine came thick and fast, and from the most divergent quarters. Especially remarkable were those which came from Erasmus Darwin in England, from Maupertuis in France, from Oken in Switzerland, and, most brilliantly of all, from Goethe in Germany.

Two men among these thinkers must be especially mentioned—Treviranus in Germany and Lamarck in France; each independently of the other drew the world more completely than ever before in this direction.

From Treviranus came, in 1802, his work on biology, and in this he gave forth the idea that from forms of life originally simple had arisen all higher organizations by gradual development;

* For Descartes in his relation to the Copernican theory, see Saisset, Descartes et ses Précurseurs; also Fouillée, Descartes, Paris, 1893, chaps. ii and iii; also other authorities cited in my chapter on Astronomy; for his relation to the theory of evolution, see the Principes de Philosophie, 3ème partie, § 45. For De Maillet, see Quatrefages, Darwin et ses Précurseurs français, chap. i, citing D'Archiac, Paléontologie, Stratigraphie, vol. i; also, Perrier, La Philosophie zoologique avant Darwin, chap. vi; also the admirable article, Evolution, by Huxley, in Encyc. Britan. The title of De Maillet's book is, Telliamed, ou Entretiens d'un Philosophe indien avec un Missionnaire français sur la Diminution de la Mer, 1748 and 1756. For Buffon, see the authorities previously given, also the chapter on Geology in this work. For the resistance of both Catholic and Protestant authorities to the Linnæan system and ideas, see Alberg, Life of Linnæus, London, 1888, pp. 143–147, and 237.

that every living creature has a capacity for receiving modifications of its structure from external influences; and that no species has become really extinct, but that it has passed into some other species. From Lamarck came about the same time his Researches, and a little later his Zoölogical Philosophy, which introduced a new factor into the process of evolution—the action of the animal itself in its efforts toward a development to suit new needs—and he gave as his principal conclusions the following:

New wants in animals give rise to new organs.

The development of these organs is in proportion to their employment.

New developments may be transmitted to offspring.

His well-known examples to illustrate these views, such as that of successive generations of giraffes lengthening their necks by stretching them to gather high-growing foliage, and of successive generations of kangaroos lengthening and strengthening their hind legs by the necessity of keeping themselves erect while jumping, provoked laughter, but the very comicality of these illustrations aided to fasten his main conclusion into men's memories.

In both these statements, imperfect as they were, great truths were embodied—truths which were sure to grow.

Lamarck's declaration, especially that the development of organs is in ratio to their employment, and his indications of the reproduction in progeny of what is gained or lost in parents by the influence of circumstances, entered as a most effective force into the development of the evolution theory.

The next great successor in the apostolate of this idea of the universe was Geoffroy Saint-Hilaire. As early as 1795 he had begun to form a theory that species are various modifications of the same type, and this theory he developed, testing it at various stages as Nature was more and more displayed before him. It fell to his lot to bear the brunt in a struggle against heavy odds which lasted many years.

For the man who now took up the warfare, avowedly for science but unconsciously for theology, was the foremost naturalist then living—Cuvier. His scientific eminence was deserved; the highest honors of his own and other countries were given him, and he bore them worthily. An Imperial Councilor under Napoleon; President of the Council of Public Instruction and Chancellor of the University under the restored Bourbons; Grand Officer of the Legion of Honor, a Peer of France, Minister of the Interior, and President of the Council of State under Louis Philippe, he was eminent in all these capacities, and yet the dignity given by such high administrative positions was as nothing compared to his leadership in natural science. Science throughout

the world acknowledged in him its chief contemporary ornament, and to this hour his fame rightly continues. But there was in him, as in Linnæus, a survival of certain theological ways of looking at the universe and certain theological conceptions of a plan of creation; it must be said, too, that while his temperament made him shy of new hypotheses, of which he had seen the birth and death of so many, his environment as a great functionary of state, honored, admired, almost adored by the greatest, not only in the state but in the Church, his solicitude lest science should receive some detriment by openly resisting the Church, which had recaptured Europe after the French Revolution and had made of its enemies its footstool—all these considerations led him to oppose the new theory. Amid the plaudits, then, of the foremost churchmen and laymen he threw across the path of the evolution doctrines the whole mass of his authority in favor of the old theory of catastrophic changes and special creations.

Geoffroy Saint-Hilaire stoutly withstood him, braving non-recognition, ill-treatment, and ridicule. Treviranus, afar off in his mathematical lecture room at Bremen, seemed simply forgotten.

But the current of evolutionary thought could not thus be checked; dammed up for a time, it broke out in new channels and in ways and places least expected; turned away from France, it appeared especially in England; great paleontologists and geologists arose there whose work culminated in that of Lyell. Specialists throughout all the world now became more vigorous than ever, gathering facts and thinking upon them in a way which caused the special creation theory to shrink more and more. Broader and more full became these various rivulets, soon to unite in one great stream of thought.

In 1813 Dr. Wells developed a theory of evolution by natural selection to account for varieties in the human race; about 1820 Dean Herbert, eminent as an authority in horticulture, avowed his conviction that species are but fixed varieties; in 1831 Patrick Matthews stumbled upon and stated the main doctrine of natural selection in evolution; and others, here and there, in Europe and America, caught an inkling of it.

But no one outside of a circle apparently uninfluential cared for these things: the Church was serene; on the continent it had obtained reactionary control of courts, cabinets, and universities; in England Dean Cockburn was denouncing Mary Somerville and the geologists to the delight of the established churchmen; and the Rev. Mellor Brown was doing the same thing for the edification of dissenters.

In America the mild suggestions of Silliman and his compeers were met by the protestations of the Andover theologians headed

by Moses Stuart. Neither of the great English universities, as a rule, took any notice of the innovators save by sneers.

To this current of thought there was joined a new element, when, in 1844, Robert Chambers published his Vestiges of Creation. The book was attractive and was widely read; in Chambers's view the several series of animated beings, from the simplest and oldest up to the highest and most recent, were the result of two distinct impulses, each given once and for all time by the Creator. The first of these was an impulse imparted to forms of life lifting them gradually through higher grades; the second was an impulse tending to modify organic substances in accordance with external circumstances; in fact, the doctrine of the book was evolution tempered by miracle, a stretching out of the creative act through all time—a pious version of Lamarck.

Two results followed—one mirth-provoking, the other leading to serious thought. As to the former, the theologians were greatly alarmed by the book; it was loudly insisted that it promoted atheism. Looking back along the line of thought which has since been developed, one feels that the Church ought to have put up public thanksgivings for Chambers's theory and public prayers that it might prove true. As to the serious result, it accustomed men's minds to a belief in evolution as in some form possibly or even probably true. In this way it was provisionally of service.

Eight years later Herbert Spencer published an essay contrasting the theories of creation and evolution, reasoning with great force in favor of the latter, showing that species had undoubtedly been modified by circumstances; but still only few and chosen men saw the significance of all these lines of reasoning which had been converging during so many years toward one conclusion.

On July 1, 1858, there were read before the Linnæan Society at London two papers—one presented by Charles Darwin, the other by Alfred Russel Wallace—and with the reading of these papers the doctrine of evolution by natural selection was born. Then and there a fatal breach was made in the great theological barrier of the continued fixity of species since the creation.

The story of these papers the scientific world knows by heart: how Charles Darwin, having been sent to the University of Cambridge to fit him for the Anglican priesthood, left it in 1831 to go upon the scientific expedition of the "Beagle"; how for five years he studied with wonderful vigor and acuteness the problems of life as revealed on land and at sea—among volcanoes and coral reefs, in forests and on the sands, from the tropics to the arctic regions; how, in the Cape de Verde and the Galapagos Islands, and in Brazil, Patagonia, and Australia he interrogated Nature with matchless persistency and skill; how he returned un-

heralded, quietly settled down to his work, and soon astonished the world with the first published results, such as his book on Coral Reefs, and the monograph on the Cirripedia; and, finally, how he presented his paper and followed it up with treatises which make him one of the great leaders in the history of human thought.

The scientific world realizes, too, more and more the power of character shown by Darwin in all this great career: the faculty of silence, the reserve of strength seen in keeping his great thought—his idea of evolution by natural selection—under silent study and meditation for nearly twenty years, giving no hint of it to the world at large, but working in every field to secure proofs or disproofs, and accumulating masses of precious material for the solution of the questions involved.

To one man only did he reveal his thought: to Dr. Joseph Hooker, to whom in 1844—under the seal of secrecy—he gave a summary of his conclusions. Not until fourteen years later occurred the event which showed him that the fullness of time had come, the letter from Alfred Russel Wallace, to whom, in brilliant researches during the decade from 1848 to 1858, in Brazil and in the Malay Archipelago, the same truth of evolution by natural selection had been revealed. Among the proofs that scientific study does no injury to the more delicate shades of sentiment is the well-known story of this letter. With it Wallace sent Darwin a memoir, which he asked him to present to the Linnæan Society; on examining it, Darwin found that Wallace had independently arrived at conclusions similar to his own—possibly had deprived him of fame; but Darwin was loyal to his friend, and his friend remained ever loyal to him. He publicly presented the paper from Wallace, and with it his own conclusions, and the date of this presentation—July 1, 1858—separates two epochs in the history, not merely of natural science, but of human thought.

In the following year, 1859, came the first installment of his thought in its fuller development—his work on The Origin of Species. In this, one at least of the great secrets at the heart of the evolutionary process, which had baffled the long line of investigators and philosophers from the days of Aristotle, was more broadly revealed. The effective mechanism of evolution was shown at work in three ascertained facts: in the struggle for existence among organized beings; in the survival of the fittest; and in heredity. These facts were presented with such wealth of minute research, wide observation, and patient collation, with such transparent honesty and judicial fairness, that they at once commanded the world's attention. It was the outcome of thirty years' work and thought by a worker and thinker of genius, but it was yet more than that—it was the outcome, also, of the work

and thought of another man of genius fifty years before. The book of Malthus on the Principle of Population, mainly founded on the fact that animals increase in a geometrical ratio, and therefore, unchecked, must encumber the earth, had been generally forgotten, and was only recalled to remembrance now and then with a sneer. But the genius of Darwin recognized in it a deeper meaning, and now the thought of Malthus was joined to the new current. Meditating upon it in connection with his own observations of the luxuriance of Nature, Darwin arrived at his doctrine of natural selection and survival of the fittest.

As the great dogmatic barrier between the old and new views of the universe was broken down, the flood of new thought pouring over the world stimulated and nourished strong growths in every field of research and reasoning; edition after edition of the book was called for; it was translated even into Japanese and Hindustani; the stagnation of scientific thought, which Buckle only a few years before had so deeply lamented, gave place to a widespread and fruitful activity; masses of accumulated observations, which had seemed stale and unprofitable, were made alive; facts formerly without meaning now found their interpretation. Under this new influence a vast army of young men took up every line of scientific investigation in every land. Epoch-making books appeared in all the great nations. Spencer, Wallace, Huxley, Galton, Tyndall, Tylor, Lubbock, Bagehot, Lewes, in England, and a phalanx of strong men in Germany, Italy, France, and America gave forth works which became authoritative in every department of biology. If some of the older men in France held back, overawed perhaps by the authority of Cuvier, the younger and more vigorous pressed on.

One source of opposition in America deserves to be especially mentioned—Louis Agassiz.

A great investigator, an inspired and inspiring teacher, a noble man, he had received and elaborated a theory of animated creation which he could not readily change. In his heart and mind still prevailed the atmosphere of the little Swiss parsonage in which he was born, and his religious and moral nature, so beautiful to all who knew him, was especially repelled by sundry evolutionists, who, in their zeal as neophytes, made proclamations having a decidedly irreligious if not immoral bearing. In addition to this was the direction his thinking had received from Cuvier; both these influences combined to prevent his acceptance of the new view.

He was the third great man who had thrown his influence as a barrier across the current of evolutionary thought. Linnæus in the second half of the eighteenth century, Cuvier in the first half and Agassiz in the second half of the nineteenth—all made

the same effort. Each remains great; but not all of them together could arrest the current. Agassiz's strong efforts throughout the United States, and indeed throughout Europe, to check it, really promoted it. From the great museum which he had founded at Cambridge, from his summer school at Penikese, from his lecture-rooms at Harvard and Cornell, his disciples went forth full of love and admiration for him, full of enthusiasm which he had aroused and into fields which he had indicated; but their powers, which he had aroused and strengthened, were devoted to developing the truth he failed to recognize; Shaler, Verrill, Packard, Hartt, Wilder, Jordan, and a multitude of others, and above all the son who bore his honored name, did justice to his memory by applying what they had received from him to research under inspiration of the new revelation.

Still another man deserves especial gratitude and honor in this great progress—Edward Livingston Youmans. He was perhaps the first in America to recognize the vast bearings of the truths presented by Darwin, Wallace, and Spencer. He became the apostle of these truths, sacrificing the brilliant career on which he had entered as a public lecturer, subordinating himself to the three leaders and giving himself to editorial drudgery in the stimulation of research and the announcement of results.

In support of the new doctrine came a world of new proofs; those which Darwin himself added in regard to the cross-fertilization of plants, and which he had adopted from embryology, led the way, and these were followed by the discoveries of Wallace, Bates, Huxley, Marsh, Cope, Leidy, Haeckel, Müller, Gaudry, and a multitude of others in all lands. The last theological efforts against these men we shall study in the next chapter.*

The Royal Institution of Great Britain, in a memorial resolution to Professor Tyndall, adopted at a general meeting, speaks of him as one "who by his brilliant abilities and laborious researches nobly promoted the objects of the institution and conspicuously enhanced its reputation, while at the same time he extended scientific truth and rendered many new additions to natural knowledge practically available for the service of mankind."

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* For Agassiz's opposition to evolution, see the Essay on Classification, vol. i, 1857, as regards Lamarck, and vol. iii, 1860, as regards Darwin; also Silliman's Journal, July, 1860; also the Atlantic Monthly, January, 1874; also his Life and Correspondence, vol. ii, p. 647; also Asa Gray, Scientific Papers, vol. ii, p. 484. A reminiscence of my own enables me to appreciate his deep ethical and religious feeling. I was passing the day with him at Nahant in 1868, consulting him regarding candidates for various scientific chairs at the newly established Cornell University, in which he took a deep interest. As we discussed one after another of the candidates he suddenly said: "Who is to be your Professor of Moral Philosophy? That is a far more important position than all the others."

THE GUESTS OF THE MAYFLOWER.

By Prof. CLARENCE M. WEED.

NO native plant has so endeared itself to the New England heart as the mayflower. For two centuries it has been to old and young the sweetest of spring's harbingers as it pushed its dainty blossoms through the fallen leaves beside the lingering snow. It has charmed those fortunate ones who have wandered over the hills to find it, and has carried glad tidings to those compelled to stay at home. It has been constantly used to carry Cupid's message from youths to maidens—a custom which I like to fancy may have originated when, in the infancy of Plymouth, John Alden brought to Priscilla Mullens bunches of arbutus blossoms that spoke not only for themselves but also for the hand that plucked them.

But *Epigœa* is a plant of decided interest in itself apart from its associations. It was not originally designed as an emissary of

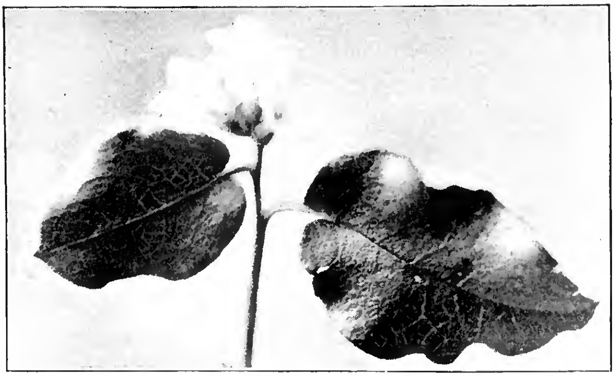

Fig. 1.—The Mayflower.

the goddess of love, and its beauty was primarily developed without reference to the æsthetic needs of the Pilgrims or their descendants. Long before the Mayflower reached Plymouth or Columbus landed at San Salvador—probably before the Indians arrived, and possibly before the glaciers came down from the north—the arbutus blossomed with each returning season and carried on the cycle of her existence as tranquilly as she does today. But her fragrance was by no means "wasted on the desert air," for she received then, as now, the tributes of a host of insect visitors that went about to do her unconscious bidding.

Although the trailing arbutus has been developing for so many centuries, it is still in a state of transition, and appears to be looking toward a goal which probably will not be fully reached

for centuries to come. Every one with the least knowledge of the vegetable world knows that the great majority of flowering plants have the stamens and pistils in the same blossom, although Nature generally devises some method of preventing self-pollination. Many species, however, bear the pistillate blossoms on one plant or part of the plant, and the staminate blossoms on another plant or part of the plant, relying on insects or the wind to carry the pollen from the latter to the former. But occasionally there occurs a species whose flowers are neither wholly one nor the other, being in a transition stage between the two. In this category we find the mayflower.

The examination of the structure of a dozen bunches of arbutus blossoms reveals a great variation in the relative conditions and positions of the stamens and pistils. In some specimens the anthers are completely abortive; in others only partially so; and in others in good condition, well filled with pollen grains. Two types of stigmas are also present: in some specimens the stigmas as a whole are broad and more or less flattened—spread out, so to speak—projecting at right angles to the style with the upper surface moist and glutinous; in others the stigmas are crowded into less space and project very little horizontally; they are drier and less glutinous, and evidently in a partially abortive condition. The perfect stigmas are usually associated with abortive anthers, and *vice versa*, so that many of the plants are already diœcious.

If the flowers are examined with reference to the length of the styles and filaments of the pistils and stamens, great variations will also be found. In some the stigmas are perfect and reach the mouth of the corolla; no anthers, and only rudiments of filaments are present. The variations I found on Blueberry Hill at Hanover, New Hampshire, may be epitomized as follows:

1. Stigmas perfect, reaching the mouth of the corolla; no anthers, and only rudiments of filaments present (Fig. 2, *a*).

2. Stigmas perfect, reaching the mouth of the corolla; anthers present, but abortive, reaching two thirds the way to the mouth of the corolla (Fig. 2, *b*).

3. Stigmas perfect, reaching half way to the mouth of the corolla; anthers abortive or absent, not reaching the stigmas.

4. Stigmas imperfect, anthers perfect; both reaching the mouth of the corolla.

5. Stigmas imperfect, anthers perfect; both reaching two thirds of the way from the base to the mouth of the corolla.

6. Stigmas imperfect, reaching slightly beyond the mouth of the corolla; anthers perfect, reaching to the mouth (Fig. 2, *c*).

The relative proportions of the different forms seem to vary with the locality. The majority of specimens I have studied belonged either in the first or fourth category. The arbutus at Han-

over is evidently tending strongly to a more perfect diœcism When it finishes its task of eliminating the filaments as it has the anthers of the stamens in many of the pistillate blossoms, and gets rid of the superfluous pistils of the staminate blossoms, it will accomplish its purposes of reproduction with less waste than at present.

A plant in the condition of the arbutus may be said to be in a certain sense at a "parting of the ways." To attain the end of cross-fertilization—the carrying of the pollen from the stamens of one plant to the pistils of another—two methods appear to be open to it. It may, and in the case of many of the Blueberry Hill specimens evidently has, become more perfectly diœcious by aborting the stamens on some plants and the pistils on others; or it might become dimorphous by developing perfect sexual organs

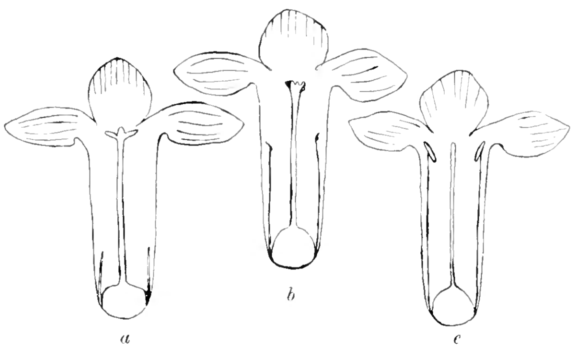

FIG. 2.—VARIATIONS OF THE MAYFLOWER.

in each blossom and having them at different heights—that is, having the stamens in one plant reach the mouth of the corolla and the pistil reach only half way to the mouth, while in another having the pistil long and the stamens short. The tendency toward dimorphism or trimorphism is shown by the varying lengths of the styles and filaments.

The blossoms of the common asparagus of our gardens show by their structure that they are in a transition stage somewhat similar to that of the arbutus. The staminate blossoms have rudimentary pistils and the pistillate blossoms rudimentary stamens, and sometimes a blossom is found which has both sets of organs in good condition—a reversion to an earlier condition of the plant.

The partridge berry,* a plant which has to contend with much the same external conditions as the arbutus, living in similar situations and remaining close to the ground, has adopted

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* *Mitchella repens.*

dimorphism as its method of securing cross-fertilization. The beautiful white blossoms of this species open early in summer. The stamens of some individuals are exserted, with the stigmas below the mouth of the corolla, while in others these conditions are reversed. Another common example of a low-growing plant with dimorphous sexual organs is that of the familiar bluets.* The dainty blossoms of this species are small individually, but grow so abundantly on New England hillsides as often to color them like a light fall of snow. A sectional view of the two forms of flowers is shown in Fig. 3: *a* represents the long-styled form with the stamens in the lower portion of the corolla tube and the stigma exserted, while in *b* the stamens are near the mouth of the corolla and the stigma is below. These blossoms are mainly pollenized by small bees and butterflies, one of the commonest New England visitors being the meadow fritillary.† When an insect

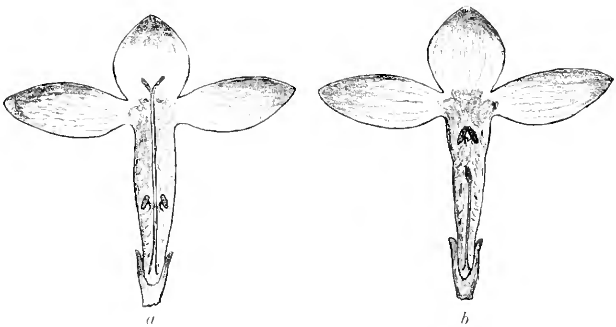

Fig. 3.—Long-styled and Short-styled Forms of Houstonia

sucks the nectar from the base of the corolla of the short-styled blossom (*b*), it will get at a certain place on its tongue some of the pollen from the anthers. If next it visits a long-styled blossom (*a*), it will be likely to brush some of this pollen on to the exserted stigma, while a point near the tip of the tongue will receive a fresh supply of pollen grains. If now it again visits a short-styled blossom, this last-received pollen will be at the right elevation to be deposited on the included stigma. Consequently, cross-fertilization will almost certainly occur.

In the case of the mayflower it is evident that the structural conditions described above will necessitate for the production of seed the transportation of the pollen from the staminate to the pistillate blossoms. The only agents to be called into play for this errand are the insects and the wind. The structure of the plant shows that under any ordinary conditions the wind would

* *Houstonia caerulea.*

† *Brenthis bellona.*

not serve the purpose, so that the insects only are left. It might at first seem that so early in the spring as the mayflower appears there would be few insects abroad —not enough to accomplish the desired results. But centuries of experience have taught the plant that the nectar hidden beneath her blushing petals will attract many visitors. On Blueberry Hill the most useful and abundant visitor is the beautiful orange-banded bumblebee.* Dozens of the large females, which have wintered over in some sheltered nook, are usually present, busily gathering the nectar concealed in the bases of the corollas. Each bee stops but a few seconds at a flower, and visits on an average three or four bunches of blossoms a minute. After alighting either on a flower or the leaves, or the ground between, the bee crawls from blossom to blossom, poking its nose, so to speak, down under the leaves that none shall be missed, and often visiting a dozen heads before taking to wings again. When the wind blows hard—a frequent occurrence on such hilltops—Madame Bombus (these early spring forms are all females, the so-called queens) flies still more rarely, crawling long distances instead. The tongue of this bee is two fifths of an inch long, and its tip readily reaches the bottom of the corolla, being thrust quickly down between the hairs. There are generally several blossoms in a single head, and, as a rule, each is plundered before the visitor departs. I saw one bee visit six heads in ninety seconds, and another seven heads in the same length of time. On the supposition that there were five blossoms per head, the first bee was plundering twenty flowers a minute. Supposing that half of each hour was spent between

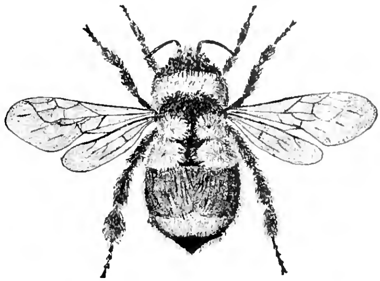

Fig. 4.—Orange-banded Bumblebee.

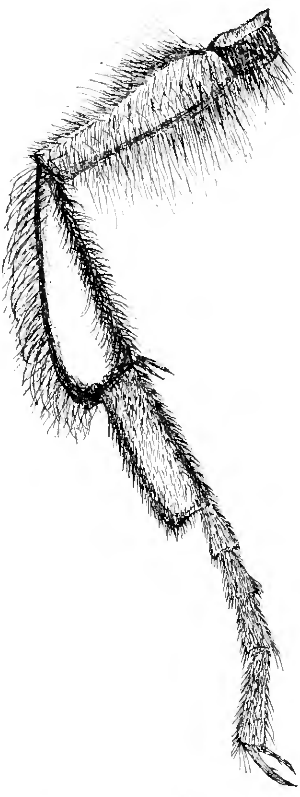

Fig. 5.—Bombus bifarius. Hind Leg.

* *Bombus bifarius* Cr.

the plants or going to the nest, the bee at this rate would visit six hundred blossoms an hour, or six thousand in a ten-hour day, if she should work so long. On the five acres of hilltop where my observations were carried on I judged that at least one hundred of these bees were at work each day. Supposing that they all worked at the above ratio, the mayflower would receive six hundred thousand daily visits. No doubt many of the blossoms are visited more than once each day, and the chances are certainly very good that each blossom will be visited at least once during the two weeks of its existence.

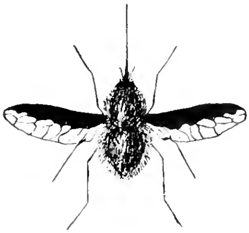

Fig. 6.—The Bee Fly.

Although the orange-banded bumblebee is much the most abundant visitor, two other related species are often seen. The commoner of these is a large and handsome *Bombus*,* black, except for two broad yellow bands—one on the thorax and the other on the abdomen. The other, which is seldom seen, is called by entomologists *Bombus consimilis*; the thorax and front half of the abdomen are yellow, with the hinder portion of the abdomen black.

By watching any one of these bees closely, one can see it stop every few minutes to brush the pollen grains off from its tongue and head, but no attempt appears to be made to collect the pollen in the beautifully developed pollen baskets on the legs (Fig. 5). These bees evidently visit the arbutus for the nectar it furnishes.

Although the bumblebees are much the most numerous and important of the mayflower's invited guests, a few other insects are found among the visitors. A rather small, two-winged fly, with a hairy, yellow body and black-banded wings, often flashes, meteor-like, from blossom to blossom. This is the handsome bee fly of the genus *Bombylius*,† one of the earliest spring insects. It has a very long tongue, which readily reaches the bottom of the mayflower corollas. I saw one of these flies stop twenty seconds at a single flower; it thrust its tongue down on one side of the pistil, then drew it out and pushed it down in another place, repeating the operation four times.

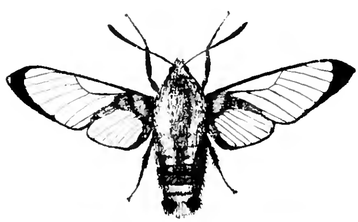

Fig. 7.—Sesia Moth

During the warmest portions of the brightest days the beautiful sesia moths appear. They are sometimes called humming-bird moths, because of their resemblance when flying to a hum-

* *B. terricola.*

† *B. fratellus.*

ming bird, though the smaller of our species, the one I find visiting the arbutus,* is more suggestive of a bumblebee. They have long tongues, curled up when not in use, through which they suck the nectar of flowers. Unlike most moths, which fly at dusk or after dark, the sesias are abroad in the bright sunlight.

Occasionally one of the early spring butterflies, especially the American tortoise-shell † and the mourning cloak, ‡ may be seen hovering over the blossoms.

The insect visitors so far considered are all useful to the mayflower. They fly rapidly from head to head and plant to plant, carrying the pollen which sticks to them from the anthers of the staminate blossoms to the stigmas of the pistillate ones, thus causing the fertilization of the embryos and the development of seeds. But the surface of the rocky hillsides where *Epigæa* is most thoroughly at home swarms with ants of various species—wingless creatures that dearly love the nectar of flowers. These insects wander everywhere in search of food, and are often seen trying to get at the honey at the bottom of the mayflower corollas. Could they succeed, little would be left for other visitors, and consequently the ants would not only be of practically no value as pollen-carriers—for rarely would one chance to wander from a staminate to a pistillate blossom—but they would also prevent the visits of the useful bees and flies. The plant, however, has fenced out these and other similar unbidden guests by an elaborate *chevaux-de-frise*, composed of hairs projecting slightly upward from the inner surface of the corolla and the outer surface of the ovary and style. It is easy for a bee, moth, or fly to push its slender tongue down through these hairs to the base of the corolla, but an ant finds it very difficult to force its body down till its mouth is at the bottom.

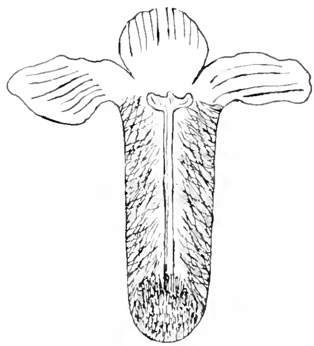

FIG. 8.—SECTIONAL VIEW OF MAYFLOWER, SHOWING HAIRS.

THE silk spider of Madagascar spins golden-colored threads, strong enough, according to M. Maindron, to hold a cork helmet by. A single female of the species, in the breeding season, gave M. Camboné about three thousand metres of fine silken thread in about twenty seven days. Small textures woven of these threads are used by the natives for fastening flowers on sunshades and for other light purposes.

* *Hemaris diffinis.* † *Aglais milberti.* ‡ *Vanessa antiopa.*

UP THE CHIMNEY.

By FRANK BOLLES.

LYING flat upon my back on my bedroom floor, with my head in the fireplace, pillowed upon the andirons, and my gaze directed intently up the chimney, I watched, hour by hour, the strange domestic doings of two of my tenants. The fireplace was so arranged, and its opening into the chimney so shaped, that I could see much of that part of the interior of the chimney which rose above me, leading toward the little patch of blue sky far away. The whole of the west wall of the black flue, and a little more than half of both the north and south walls, were visible to me. The surface of these walls was rough, having been daubed with mortar which formed undulations and ridges. The lower faces of these irregularities were soft, dull black, but the parts inclined toward the sky caught the glare of light from above and shone as though ebonized. About eight feet above me, as I lay in the second-story fireplace, something about the size of half a small saucer projected like a tree fungus from the northern wall of the flue. Its edges gleamed like silvery gelatin, and light shone through its fabric in many places. This fabric seemed to be made of dozens of small twigs matted and woven together in semi-saucer form, and held firmly in place by some translucent, gelatinous substance of a yellowish-white color. Masses of the same substance held the shallow nest in its place against the hard, cold wall of brick and mortar. Protruding from the nest were the long and slender wings of a bird, which was sitting snugly upon the structure, with her face turned directly to the bricks. The tapering wings crossed near the body, and their tips spread like a Y, under which a short, stiff, fan-shaped tail extended, for a part of the distance covered by the wings. These stiff tail feathers, kept spread all the time, terminated in sharp spines, readily discernible. Occasionally, as I watched, the sitting bird wriggled on her nest, and her wings moved restlessly.

Suddenly the column of air in the chimney was thrown into vibration, and a dull booming sound resulted. Something darkened the opening of the shaft, the interrupted light trembled in a confusing way; I was strongly inclined to get out from under, and found it impossible to avoid closing my eyes. Simultaneously with these disturbing events, a bird's voice in the chimney produced a series of rapid whistling or peeping notes, so mingled as to render the hearer uncertain as to the number of birds making them. A second bird had entered the chimney. Seen from outside, he had dropped into it, and, watched by perturbed vision

from below, he had come down backward, hovering and fluttering until, head toward the light, his tiny feet had caught in the mortar and every spine in his very brief tail had been braced against the same rough substance. Perfectly motionless, he clung to the black wall as a tree toad sticks to a tree trunk. His flat head, tiny beak, sooty brown coat, shining in the glare from the sky, did not combine well into a bird; in fact, nothing in their weird surroundings made these tenants seem akin to birds. They were more like bats.

Outside, the hot sunlight and hazy blue sky of early July hung over wood and meadow, lake and distant mountain. Butterflies fluttered and drifted in aimless flight over the sumacs, a humming bird buzzed in the deep blue larkspur flowers, barn swallows cut fanciful curves over the lake and back to their nest with its nestlings; while down in the shadowy fern land the veery's tremulous music told of coolness and comfort. How different this soot lined tube of brick, leading down through ever-darkening gloom into an unknown abyss of blackness and silence! How strange that this keen-eyed swift, which a moment ago was speeding through highest ether at a rate which no other bird can equal and maintain, should come back into this pit and call it his home! He spoke again, and once more the heavy air of the chimney responded to his whirring wings, as he dropped a little lower to the level of the nest, and turned his bright eyes inquiringly toward his mate. Her wings now moved, and she lifted herself away from the frail platform of glued twigs and stuck against the bricks a few feet distant. The male, raising his wings and keeping them moving, walked flylike to the nest and settled upon it. Instead of facing directly toward the north wall, he sat upon the nest at a different angle, so that his forked wings projected obliquely from the nest's edge. A moment later the female made the air throb and boom to her powerful flight as she flew toward and into the light.

Twenty minutes passed; the bird on the nest was restless, and squirmed in a way which suggested physical discomfort. Then he gave a low call; and a moment later darkness, hurried notes, and the fluttering of strong wings announced the mother-bird's return. She dropped down backward until close beside the nest, struck and clung to the bricks, and then, using her feet almost as well as though on level ground, gained the nest and pushed her way upon it, fairly forcing off her mate, who seemed to have no inclination to depart. Finally he moved, and, after a series of short upward flights, regained the sunlight, and was seen no more for three quarters of an hour. As the female settled herself upon the nest, a faint "cheeping" suggested that tiny life was stirring beneath her breast. Her position was the same which

she took in the first instance, her face being turned so directly toward the north wall that her tail projected at right angles from the nest. After seeing half a dozen exchanges in position made by the birds, I was satisfied that one parent, which I called the female, always sat straight upon the nest, and the other, which for the sake of distinguishing them I called the male, always sat obliquely.

To see only the bottom of the nest, yet to know that within it lay young swifts which were being fed in some way by their parents, was tantalizing. I recalled a former year, when I wished to secure a swift's nest with its full set of eggs, and so had kept watch of the nest; not by climbing to the chimney top and peering down, but by raising a small mirror, by whose aid I had seen the reflected nest from below. The mirror served its purpose a second time. I lashed it to the tip of a fishing rod, and pushed the slender joint up the chimney, adding first the middle joint and then the butt, in order to bring the glass well above the nest. Something white was in the nest—just what, I could not at first tell, for mortar dust had fallen into my eyes, and it was difficult to keep the glass still enough to see with my eyes blinking and weeping. The mother-bird had been driven from the nest by the appearance of the strange, misshapen thing which I had forced toward her from below, and she was now making short flights back and forth in the upper part of the chimney, producing sounds and sudden variations in light and darkness which would surely have frightened away any but a human intruder. Wiping my eyes and steadying the glass, I took a careful look at the contents of the nest. The white object, or at all events its whitest part, was an eggshell from whose opened halves a young bird was feebly trying to escape. Without waiting to see more, I withdrew the mirror from the chimney and removed all disturbing objects, myself included, from the fireplace. My heart reproached me. Had my violence driven the birds from their nest, thus making probable the death of the young at this trying crisis in their career? More than fifteen minutes passed before booming wings in the swift's grewsome nursery assured me that a parent had returned.

These events happened on Monday, and not until the following Saturday did I again intrude upon my batlike neighbors. Meanwhile I was not unaware of their near presence, for at all hours of the day and night the thunder of their wings and their high-pitched voices invaded my room. After exchanging places at intervals of from fifteen to forty-five minutes all day long, it seemed to my human intelligence that they might keep still at night. But no, during evening twilight, and at ten, twelve, one, and three o'clock, and then with tenfold energy between dawn

and six in the morning, they came and went, went and came with apparently sleepless energy. The nights were clear and dry, and in the sky or over the white surface of the lake, insects were probably easily seen at any hour by birds accustomed to such gloom as that of my chimney. Still it was wonderful to think of their strength and patience, and of their knowledge of place. Many, if not most, of us poor mortals lose our paths under the simplest conditions, even with the sun smiling down upon us, or the stars writing their ancient guideboards anew for us in the dark heavens, toward which we will not turn for aid. These swifts, however, seem to plow through darkness or light with equal confidence, cleaving the cool wind at the rate of more than a mile a minute, seeing first the pale lake below their chimney's shadow, then the vast peak of Chocorua, framed in its somber spruces, and again some far range of untrodden mountains where fellow swifts still nest in hollow tree trunks, after the ancient practice of their family. What marvelous sense is it which brings them back by day or by night, in sunlight or in storm, straight as thought itself, to home and rest?

I never have met a man who remembered having seen a swift perch. It was formerly supposed that they had no feet, and some people still believe the fable. In building time the birds come spinning through the air like projectiles, and while flying thus, snap small terminal twigs from sycamores and other brittle trees, and carry them back to their chimneys, to be painstakingly glued into their fragile nests. After seeing my swifts use their feet so readily in getting to and from their nest, I shall not be much surprised some day to see a swift alight upon some convenient perch outside his chimney. Nevertheless, so far as is now known, the swifts take no rest even after flying many miles with incredible speed, until their accustomed shelter is regained.

When Saturday came, I felt that it was time to see more of my noisy tenants. In the intervening days something which looked like a happy thought had come to me. Why should I lie supine among the fire irons, gazing up the black chimney hole, when, by judicious use of a few mirrors, I could bring the swifts and their cavern within range of my writing table? Saturday morning the small mirror climbed the flue a second time, and was firmly lashed in position a few inches above the nest. The lashing, of course, was applied to the butt of the fishing rod, at the point where it rested in the fireplace among andirons and tongs. Then a narrow, old-fashioned mirror, in which somebody's great-grandmother may have admired her pretty face in the days of a long-forgotten honeymoon, was gently rested upon the single stick of wood at the back of the fireplace so that its face inclined slightly toward me. Wonderful!—there were the shiny flue, the

nest, the frightened bird perching far up the shaft, and the narrow line of sky above her; and there also was the small glass at the tip of my fishing rod, and in its oval face was an image of the inside of the shallow nest with two fat, featherless, sightless swifts flopping about in it. Nothing could now be easier than to watch the entire process of rearing the infant projectiles from a state of feebleness and imbecility to that marvelous condition of grace, speed, and intelligence at which they would, in the natural course of events, arrive in a few brief days.

My first desire was to ascertain how they were fed. The barn swallows, who by some freak have taken possession of a pewee's nest just under the eaves of my cottage, feed their young with insects which they bring bristling in their beaks. I had expected to see the swifts bring insects to their babies, but my closest scrutiny failed to discover anything in their beaks when they arrived, or when they went upon the nest. Under the new conditions I watched with double care and attention. At first, for nearly an hour, the birds were too much disturbed by the glass and fishing rod to settle upon the nest. They came close to it and chattered, but flew nervously and noisily, as though to frighten away the intruder. After a while they grew quieter, and finally one arrived with food. She came to the nest, mounted its edge, and leaned toward the open-mouthed young. Then she moved violently, and seemed to hang over the infants, to pound them, shake them, and push them back and forth in a singularly rough and unkind way. Seeing all these things by double reflection and in the dim light of the chimney, I could not be certain of details, but all that I saw reminded me of descriptions I had heard and read, of feeding young birds by regurgitation, while nothing that went on looked like the quiet and matter-of-fact process of dropping a fly into a little bird's gaping mouth. It seemed to me that the parent inserted her bill in the young one's throat, and then presumably pumped into it, by the violent motions which she made, a portion of the food previously swallowed by her. After being fed, the young dropped back limp or satisfied into the nest, and were promptly sat upon and hustled into a comfortable and orderly condition. Apparently both birds joined in feeding their offspring, for I saw first one and then the other go through this peculiar process.

Supposing that I should have ample opportunity for several days to watch the feeding, I did not devote myself to its study as faithfully as I should have, had I foreseen the distressing event which was in store for my tenants. On Saturday afternoon a light rain fell. The faithful mother sat upon her nest while multitudes of tiny drops floated down the chimney. They did not fall, but seemed to sail unwillingly through the gloom, held aloft

by the ascending currents of air. Each globule shone with light, and looked almost as white as a snowflake. As they approached the nest few seemed to touch it, but curved away from it in some eddy of the air, and settled down into the depths of darkness below. During the rain both birds remained in the chimney most of the time. Sunday, July 16th, proved to be an unusually warm day, and, what was perhaps of more moment to the swifts, a very dry day, there seeming to be no moisture left in air or vegetation. About noon, while writing at my table, I heard the familiar booming, whistling, and chirping in the chimney, and as I glanced up I saw that one of the birds was coming to the nest and the other just going off up chimney. Suddenly there was a grating sound, a sharp outcry, more booming and fluttering, and I jumped to my feet and knelt before the glass to gain a closer view of the chimney. The nest had vanished. Only a tiny piece of glue adhered to the slight curve in the bricks under which the nest had been attached. The parent bird, with ruffled plumage and rapidly moving head, clung near the spot where her home had been, and seemed to me to be looking with terror far down into that horrible abyss where her young had fallen, and from which they sent back no cry. Taking down the pointed rod, I used the small mirror to search every part of the great chimney cavern which could be reached, but in vain. The nest had gone straight down without touching any fireplace, and had been lost forever in the *débris* and stifling dust at the bottom of the shaft.

During the remainder of the day the birds fluttered back and forth and lamented. They did not go more than two or three inches below the spot where the ill-fated nest had been. At intervals during the night I heard them moving in the chimney, but on Monday they stayed away most of the time, even during a heavy shower which fell late in the afternoon. Toward evening I saw both of them perched near the site of their fallen home, and during that night and on other days and nights the sound of their wings occasionally came to me as a reminder of their vanished happiness. They made no effort to rebuild in my chimney, yet their presence in it seemed to show that they had not begun housekeeping elsewhere. I doubt not that another summer, that love of home which is so closely connected with birds' ability to find a familiar spot by day or by night, even after months of absence, will bring my swifts back to their old flue.

It appears from the altitudes of the highest clouds measured at Upsala, Sweden, Kew, England, and Blue Hill, Mass., that the upper limit of ordinary clouds in temperate latitudes is between thirteen and fifteen kilometres, or nine miles; but it is possible that more numerous measurements may extend it to ten miles.

FROST-FORMS ON ROAN MOUNTAIN.

By Mrs. HELEN R. EDSON.

THIS is the only habitable high mountain peak east of the Pacific ranges. Its altitude, six thousand three hundred and thirteen feet above the sea level, tempered by its latitude, thirty-six degrees, together with its isolation from other mountains of similar height, renders it one of the most favorable places for the observation of atmospheric conditions. The clouds here usually float about level with the summit, though they sometimes rise as much as five hundred feet above it, or sink two

Fig. 1.

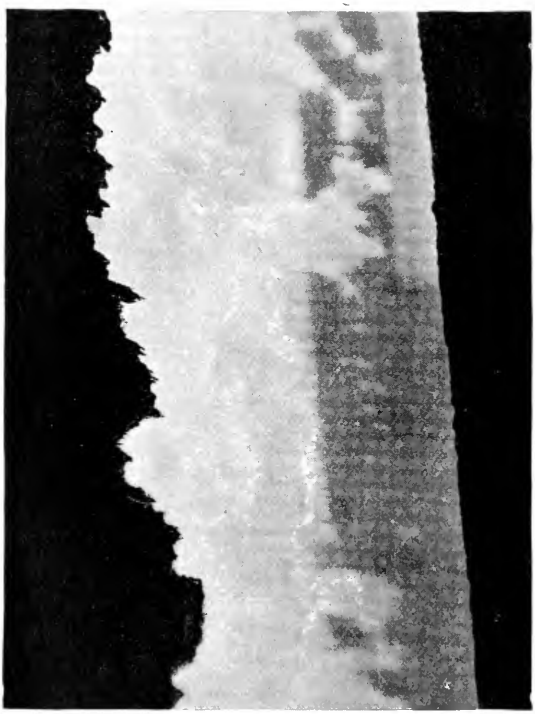

Fig. 2.

thousand feet below; so that it may be said to lie in the track of the clouds.

I regret that I was not better equipped for a thorough study of frost-forms produced by the lateral deposit of the frozen vapor in the clouds during the severe winter of 1892–'93, which I spent upon the summit of Roan Mountain for the sake of an invalid daughter. There was not a hygrometer within reach, hence the amount of moisture in the atmosphere at any given time can not

be stated. The anemometer was frequently clogged by accumulations of frost upon it. Incessant winds and flying snow dust prevented the taking of clear photographs out of doors, and many plates were spoiled by inexperienced handling.

The factors in the production of these frost-forms are the frozen vapor and the wind. Their size, shape, and location are

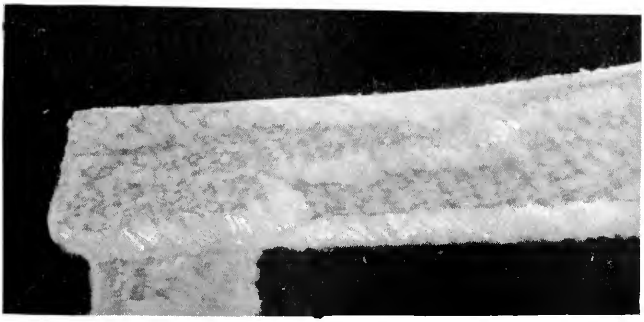

FIG. 3.

controlled by the amount of moisture, the temperature, the direction and velocity of the wind, the shape, size, and situation of the objects on which they are deposited, and the size and nearness of the surrounding objects. The lower the temperature, the denser the cloud, the swifter the wind, and the more perfect the exposure, the more rapid the growth and the more profuse and elaborate the results.

Fig. 1 shows a six-sided wooden pillar with a deposit made in two hours. Wind, about thirty miles an hour; temperature, fifteen degrees below zero. Frost in the form of fir-tips, projecting three quarters of an inch from the corners, and one fourth to one half inch from the spaces intervening. A space two inches square contained twenty-five.

Fig. 2 shows the same pillar a week later, after five days of storm and two of sunshine. Frost-forms now projecting fourteen inches and glazed on outside.

There is no fixed proportion between the size of the base of the deposit and the deposit itself. It is remarkable for cohesive strength, stiffness, and tenacious grip upon its base. In the case of round bodies, such as trees or wires, it clasps but half the circumference, the other half being not even glazed (unless some large object be directly to leeward), and stands out on the windward side of its support, following its curves and angles with precision. Sometimes a tree or a grove of trees may be seen entirely white on one side and green on the other.

Unless there are numerous changes in the direction of the wind during the progress of construction, the first aggregations

of particles have the same general configuration as the finished ornaments hundreds of times as large—six to eight inches wide at the base and projecting twelve to sixteen inches. A slight variation in the direction or velocity of the wind makes them more complex and adds greatly to their beauty; but a change of as much as sixty degrees in the direction wrenches them from their supports. They come away entire, and lie in heaps under the trees like autumn leaves, and may be collected and preserved in a cold, sheltered place until they gradually evaporate.

The process of formation is an interesting study. It is impossible to follow the course of the fine particles of snow dust which make up the most beautiful forms; but at a temperature of twenty-five to thirty degrees above zero the frozen moisture

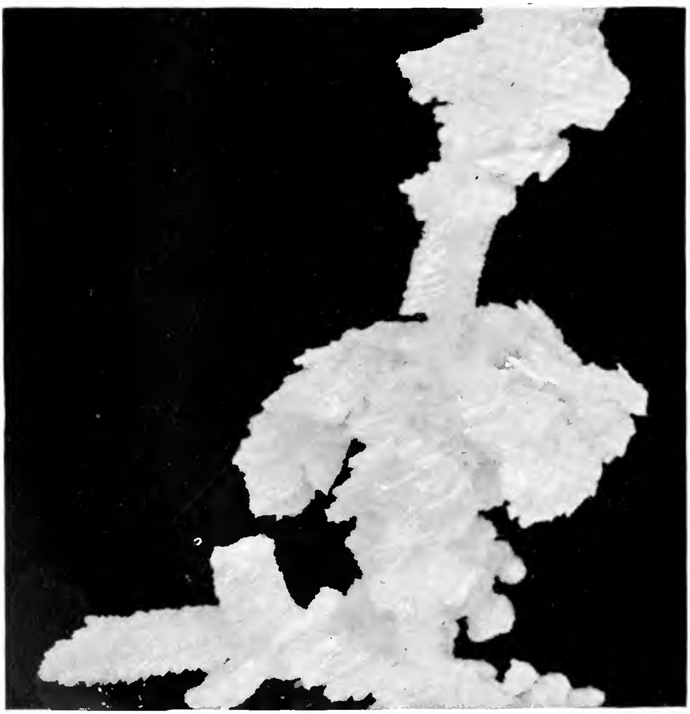

Fig. 4.

comes in minute pellets of ice which may be watched with a good microscope as they strike a chosen spot. The development of the ice-forms is much more rapid than that of the snow-forms; otherwise the processes seem to be identical.

On the edges of flat surfaces, and along the diameters of round bodies, lines of particles are deposited as the wind rushes past the obstruction. Then begins a twofold growth, caused by the direct

application of other particles on the windward side, and by the rebound to the lines already laid of those particles which are driven violently against the surfaces between the lines. On smooth, narrow bodies, as this process is continued, the deposits along the sides or edges soon become so thick and long as to meet in the middle. On rough surfaces new lines and centers of groups are begun on all projections, however slight, and the particles rebound to them from the surrounding surfaces.

Fig. 3, a section of rough board, illustrates this. The deviation from the perpendicular in the frost-forms on the edges is due to the fact that the board was not accurately facing the wind.

There is, of course, a great variety of forms produced in different storms, all wonderful for delicacy of design and perfection of finish such as could not be imitated in any material.

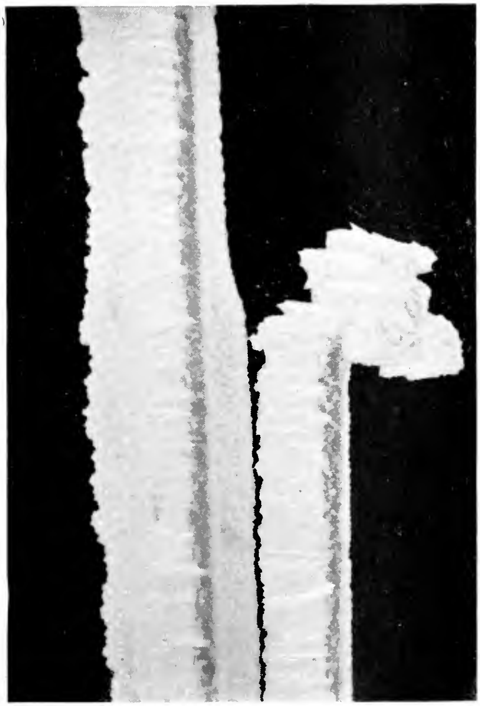

Fig. 5.

Fig. 6.

Among them may be shown a branch of balsam fir (*Abies Fraseri*) (Fig. 4) which bears the heavy fringe of the storm of December 28th, when the wind blew at the rate of fifteen to twenty-five miles an hour, and the temperature was fifteen degrees above zero.

Fig. 5, a pillar and standpipe, shows the perfect fir-tip pattern of January 3d. Wind, fifteen to thirty miles an hour; temperature, ten degrees below zero. The lower temperature and swifter wind account mainly for the difference between this form and the preceding one. The leeward sides of pillar and pipe are thinly coated by the rebound of particles from the house wall.

Fig. 6, the accumulation on the tip of a blade of grass, seven eighths of an inch long. This fragment was broken off and brought into the house to show how all the grass was decorated by the storm of January 6th, with wind at forty miles an hour and temperature twenty degrees below zero. It was two inches and three quarters tall and weighed three quarters of an ounce avoirdupois, or more than five thousand times as much as the bit of grass inclosed by it. It was composed of ten large feathers, with the spaces between them filled with smaller ones—no shapeless snow about it. The tips of twigs, ends of fence rails, etc., projecting toward the wind, were all similarly decorated, but on different scales, according to their size and exposure.

Many curious and apparently contradictory effects are produced by the rebound from one surface to another. A post which

Fig. 7.

stood twenty feet from the house, in a small court inclosed on three sides, had a deposit on the face toward the house equal to that on the windward side, while the other sides were bare and dry.

Fig. 7 shows a wreath of plumes averaging six inches in length, formed altogether upon the leeward side of a tub, by the rebound of the vapor-laden wind from a high wall about three feet distant. It will be seen that the rebound from the tub again has produced a second series of forms around it on the ground, pointing toward the tub.

The most conspicuous and noteworthy example of this resili-

ent force was exhibited at the close of the storm of January 6th to 8th, in a recess where a north wing joins the main hotel building. The speed of the wind varied from forty to sixty miles an hour during those three days, and the temperature was from fifteen to thirty degrees below zero.

Fig. 8 presents a sketch of the outlines. A B is the northwest corner of the main building, three stories high. C is two stories high, and E D one story. F shows the direction of the wind, which varied little. A, B, D, and E had heavy, deep cornices of long, narrow plumes like pampas grass, averaging sixteen inches in length, inclined outward from base to tip at an angle of thirty degrees to the plane of the wall, and lying in a horizontal position. The plumes on A and E pointed north by northwest; those on B, west by northwest; all as directly toward the wind as was allowed by the laws governing their application to the walls and by the angles at which the wind struck the walls. Those on D, being formed by the rebound from the high wall C and the angle C B, pointed east, or toward C, though in all other respects similar to the others. On the weatherboards of A, B, and E the frost-feathers were short and broad. They stood vertically, with their bases on the edges of the boards, each row overlapping the row above, and each row formed by the downward rebound of particles from the thick edge of the board above it. The forms on all the upright corner boards (or facing boards) seemed to have been made later than those on the weatherboards, since they lay horizontally, with their tips pointing toward those on the weatherboards, and at a right angle to them. They must have been made by the rebound from the forms on the weatherboards, as their direction in every instance was exactly opposite to that of the cornice decorations on the same wall. After the first few hours it was impossible to brave the fury of the storm to watch the process of development, which is inferred from the results and the proved rules by which the work is done.

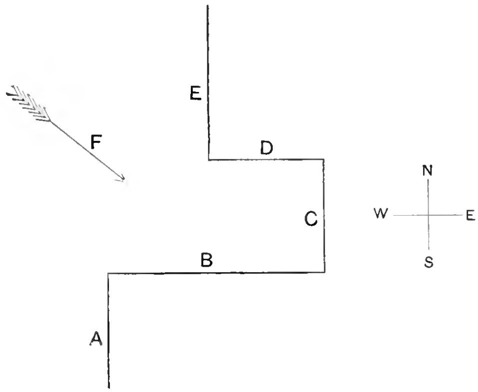

Fig. 8.

The forms on the weatherboards of D hung downward, while those on the opposite wall, B, stood upright. This must have been due to the rotary motion of the wind after it struck the three-story wall B and the two-story wall C, and, whirling down-

ward and upward again from the ground, struck the one-story wall D.

Fig. 9 shows a section of the wall D in the beginning of that storm. Unfortunately, the other negatives of that group were spoiled.

On C the deposits on cornice and weatherboards nearest D partook of the shape and direction of those on D; and the same

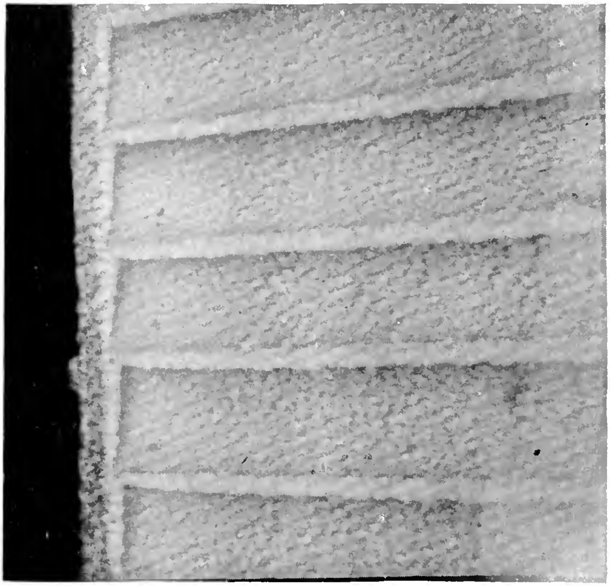

Fig. 9.

was true of those nearest B. In the space intervening, the frost was laid on obliquely, resembling the first course of a heavy lattice. All these walls, as well as all others on the mountain top which faced the west and north, were completely covered, and presented the appearance of exquisitely chiseled marble.

On all flat surfaces, whether curved or rectilinear in outline, when they are suspended vertically, faced to the wind, so that it may blow past all sides unobstructed, the frost-forms lie at an angle of thirty degrees to the surface, with their bases to its edges, and point accurately toward the center.

On a flat surface having a rim that projects as much as half an inch, they are built on the inner edge of the rim, and extend toward the center at a right angle to the rim and parallel to the surface. When the rim is more shallow, their bases are set in the angle where the rim joins the surface, and they stand out from the surface at an angle of more than thirty degrees.

Fig. 10 is the lid of a cream freezer, showing frost-forms point-

ing toward the center and extending parallel to the face of the disk.

On a tumbler, three inches and a quarter in depth and two inches and a quarter in diameter at the top, placed with its mouth to the wind, the result was the same. The frost-forms pointed toward the center and were parallel to the bottom of the tumbler. It might be worth while to find out by experiments how deep and how wide a vessel would be required to cause them to deviate from this rule.

Fig. 11 exhibits an iron pipe elbow, part of the deposit on which was affected by the rebound from the longer curved side as the wind passed through it. If a straight section of pipe be placed so that the wind may pass through it unobstructed, the deposit is made on the windward end, of the same thickness as the metal; and it appears as though that part of the pipe had been

FIG. 10.

cast in the pattern prevailing in that storm, and whitened. The outer and inner longitudinal surfaces of the pipe are left bare and dry.

Very pretty experiments may be made with apples, chairs, wheels, tin cans, feathers, and other objects too numerous to mention.

Fig. 12 is an apple with a faithful imitation of a chrysanthemum on one side. This was made at a low temperature and was white. The most beautiful blossoms were those made of sleet, at a temperature of twenty-five to thirty degrees above zero. They

were sometimes as large as the apples, and always had from twelve to twenty perfectly shaped petals, from one inch to two inches and three quarters long.

It often happens that the clouds clear away and the temperature rises a few degrees while the direction of the wind is still unchanged. Then the outer surfaces of the frost-forms become glazed and the softer filling is blown out. They may be taken off entire, and need no greater care in handling than fine china. They are thin as eggshells and translucent, and under the microscope show long rows of minute cells, separated by delicate filiform partitions. A contrary wind unclasps their hold and the ground is strewn with the curious wreckage. They may be kept for many days in a cold place.

In sheltered places, a little way down on the leeward side of the mountain, the deposits of frozen vapor are similar to the hoarfrost seen in the lowlands, but greatly exaggerated in size and profusion, and are usually in the form of small rosettes, set as thickly as possible upon all surfaces of trees, rocks, or buildings.

The frost on the windows of all unoccupied rooms varies in shape and amount according as the temperature is higher or lower. At fifteen degrees above zero, small fern-shaped figures are made, about a quarter or a half an inch long. At lower temperatures they decrease in size and increase in numbers, until,

Fig. 11.

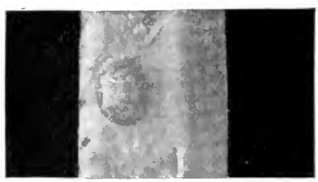

Fig. 12.

at thirty degrees below zero, the panes are quite covered with tiny frost ferns, twenty-five of which have been counted in a space an inch square, every one perfect in outline. Above fifteen degrees above zero the shape changes to something like the *Hypnum* moss.

Fig. 13 represents part of a pane. The temperature fell below fifteen degrees for a short time, allowing the accumulation of a few of the fern-forms, and then rose rapidly to twenty-five degrees, with the result here shown. The moisture condenses upon the windows of inhabited rooms just about as it does everywhere else.

I watched throughout the winter for the stellar and hexagonal snowflakes, but never found them while the clouds enveloped the mountain. The particles of frozen vapor in the clouds resemble finely ground meal. When a cloud rises from fifteen to

FIG. 13.

twenty feet above any given place, several of these particles (usually six or eight) come down joined together like beads on a pin; when it rises fifty or a hundred feet, the little sticks of globules cross and adhere to each other in falling, and reach the earth in all the complex shapes commonly called snow crystals.

NOTHING escapes the ravages of insects, not even books. One of the insect "enemies of books" is the *Lepisma saccharina*, often called the silver fish, which is marked by its luster and its activity. Prof. Westwood once named a minute beetle, which had done much mischief to the cover of a book, *Hypothenemus crudites*. Specimens of books damaged by insects are exhibited in the South Kensington Museum, London. Mr. Zaehnsdorf, a bookbinder, has formed a collection of the book pests which he has met in the exercise of his calling. The Arabs are said to write sometimes the name *Kabikaj*, the name of a genius who presides over insects, on their manuscripts, in order to protect them from the ravages of his subjects.

THE ICE AGE AND ITS WORK.

By ALFRED R. WALLACE, F. R. S.

EROSION OF LAKE BASINS.

III.

LAKES are distributed very unequally over the various parts of the world, and they also differ much in their position in relation to other physical peculiarities of the surface. Most of the great continents have a considerable number of lakes, many of great size, situated on plateaus or in central basins; while the northern parts of Europe and North America are thickly strewn with lakes of various dimensions, some on the plains, others in subalpine valleys, others again high up among the mountains, these latter being of small size and usually called tarns. The three classes of lakes last mentioned occur in the greatest profusion in glaciated districts, while they are almost absent elsewhere; and it was this peculiarity of general distribution, together with the observation that all the valley lakes of Switzerland and of our own country occurred in the track of the old glaciers, and in situations where the erosive power of the ice would tend to form rock-closed basins, that appears to have led the late Sir Andrew Ramsay to formulate his theory of ice-erosion to explain them. He was further greatly influenced by the extreme difficulty or inadequacy of any possible alternative theory—a difficulty which we shall see remains as great now as at the time he wrote.

This question of the origin of the lake basins of the glaciated regions is especially interesting on account of the extreme divergence of opinion that still prevails on the subject. While the general facts of glaciation, the extent and thickness of the old glaciers and ice-sheets, and the work they did in distributing huge erratics many hundred miles from their sources and in covering thousands of square miles of country with thick layers of bowlder clay and drift, are all admitted as beyond dispute, geologists are still divided into two hostile camps when the origin of lake basins is concerned; and the opposing forces seem to be approximately equal. Having for many years given much attention to this problem, which has had for me a kind of fascination, I am convinced that the evidence in favor of glaciation has not been set forth in all its cumulative force, while many of the arguments against it seem to me to be either illogical or beside the point at issue. I have also to adduce certain considerations which have hitherto been overlooked, but which appear to me to afford very strong if not conclusive evidence for erosion as against any alternative theory yet proposed. I shall, therefore, first set forth, as

fully as the space at my command will allow, the general evidence in favor of the ice origin of certain classes of lakes, and the special conditions requisite for the production of lakes by this agency. The objections of the best authorities will then be considered and replied to, and the extreme difficulties of the alternative theories will be pointed out. I shall then describe certain peculiarities, hitherto unnoticed, which clearly point to erosion, as opposed to any form of subsidence and upheaval, in the formation of the lakes in question. Lastly, the special case of the Lake of Geneva will be discussed, as affording a battle ground that will be admitted to be highly favorable to the anti-glacialists, since most of them have adduced it as being entirely beyond the powers of the ancient glaciers to have produced.

THE DIFFERENT KINDS OF LAKES AND THEIR DISTRIBUTION.—To clear the ground at the outset, it may be well to state that the great plateau lakes of various parts of the world have no doubt been formed by some kind of earth movements occurring subsequent to the upheaval and partial denudation of the country. It is universally admitted that existing lakes can not be very ancient, geologically speaking, since they would inevitably be filled up by the sediment carried into them by the streams and by the wind. Our lakes must, therefore, be quite modern features of the earth's surface. A considerable proportion of these plateau lakes are in regions of little rainfall, and many of them have no outlet. The latter circumstance is a consequence of the former, since it indicates that evaporation balances the inflow. This would have favored the formation of such lakes, since it would have prevented the overflow of the water from the slight hollow first formed, and the cutting of an outlet gorge which would empty the incipient lake. Captain Dutton, in his account of the geology of the Grand Cañon district, lays stress on this fact, "that the elevation of a platform across the track of a river rarely diverts it from its course, for the stream saws its bed into the rocks as fast as the obstacle rises." Scanty rainfall and great evaporation seem therefore to be almost essential to the formation of the larger plateau lakes. Rarely, such lakes may have been formed in comparatively well-watered districts, but the earth movements must in these cases have been exceptionally rapid and extensive, and they are accordingly found most often in countries subject to volcanic disturbances. Such are the lakes of southern Italy, of Macedonia, of Asia Minor, and perhaps those of Central Africa.

Quite distinct from these are the subalpine lakes of those mountain groups which have been subject to extreme glaciation. These are characteristically valley lakes, occurring in the lower portions of the valleys which have been the beds of enormous glaciers, their frequency, their size, and their depth bearing some

relation to the form and slope of the valleys and the intensity of the glaciation to which they have been subject. In our own country we have in Wales a small number of valley lakes; in the Lake District, where the ice-sheet can be proved to have been much thicker and to have lasted longer, we have more numerous, larger, and deeper lakes; and in Scotland, still more severely glaciated, the lakes are yet more numerous, many of those in the west opening out to the sea and forming the lochs and sounds of the western Highlands. Coming to Switzerland, which, as we have seen, bears indications of glaciation on a most gigantic scale, we find a grand series of valley lakes both on the north and south, situated for the most part in the tracks of those enormous glaciers whose former existence and great development are clearly proved by the vast moraines of northern Italy and the traveled blocks of Switzerland and France. In Scandinavia, where the Ice age reigned longest and with greatest power, lakes abound in almost all the valleys of the eastern slope, while on the west the fiords or submerged lakes are equally characteristic.

In North America, to the south of the St. Lawrence River and of Lakes Ontario and Erie, there are numbers of true valley lakes, as there are also in Canada, besides innumerable others scattered over the open country, especially in the north, where the ice-sheet must have been thickest and have lingered longest. And in the southern hemisphere we have, in New Zealand, a reproduction of these phenomena—a grand mountain range with existing glaciers, indications that these glaciers were recently much more extensive, a series of fine valley lakes forming a true lake district, rivaling that of Switzerland in extent and beauty, with fiords on the southwest coast comparable with those of Norway.

Besides these valley lakes there are two other kinds of lakes always found in strongly glaciated regions. These are Alpine tarns—small lakes occurring at high elevations and very often at the heads of valleys under lofty precipices; and small or large plateau or low-level lakes which occur literally by thousands in northern Canada, in Sweden, Finland, Lapland, and northwestern Russia. The valley lakes and the Alpine tarns are admitted by all geologists to be mostly true rock basins, while the plateau and low-country lakes are many of them hollows in the drift with which much of the country is covered, though rock basins are also not infrequent.

Here, then, we see a remarkable association of lakes of various kinds with highly glaciated regions. The question is whether there is any relation of cause and effect in the association; and to determine this we must take a rapid survey of other mountain regions where indications of ice action are comparatively slight or altogether wanting, and see whether similar lakes

occur there also. The comparison will, I think, prove very instructive.

Spain and Portugal are pre-eminently mountainous countries, there being a succession of distinct ranges and isolated mountain groups from east to west and from north to south; yet there is not a single valley lake in the whole peninsula, and but very few mountain tarns. Sardinia and Corsica are wholly mountainous, but they do not appear to possess a single valley lake. Nor does the whole range of the Apennines, though there are many large plateau lakes in southern Italy. Farther south we have the lofty Atlas Mountains, but giving rise to no subalpine valley lakes. The innumerable mountains and valleys of Asia Minor have no lakes but those of the plateaus; neither has the grand range of the Lebanon, a hundred miles long, and giving rise to an abundance of rivers. Turning to the peninsula of India, we have the ranges of the Ghauts, eight hundred miles long, the mountain mass of the Neilgherries and that of Ceylon, all without such lakes as we are seeking, though Ceylon has a few plateau lakes in the north. The same phenomenon meets us in South Africa and Madagascar—abundance of mountains and rivers, but no valley lakes. In Australia, again, the whole great range of mountains from the uplands of Victoria, through New South Wales and Queensland to the peninsula of Cape York, has not a single true valley lake. Turning now to the New World, we find no valley lakes in the southern Alleghanies, while the grand mountains of Mexico and Central America have a few plateau lakes, but none of the class we are seeking. The extremely mountainous islands of the West Indies—Cuba, Hayti, and Jamaica—are equally deficient. In South America we have on the east the two great mountain systems of Guiana and Brazil, furrowed with valleys and rich in mountain streams, but none of these are adorned with lakes. And, lastly, the grand ranges of the equatorial Andes, for ten degrees on each side of the equator, produce only a few small lakes on the high plateaus, and a few in the great lowland river plains—probably the sites of old river channels—but no valley lakes in any way comparable with those of Switzerland or even of our own insignificant mountains.

Having thus roughly surveyed the chief mountain regions of the whole world, we find that true subalpine valley lakes—that is, lakes in the lower parts of the valleys descending from mountain ranges or groups, filling up those valleys for a considerable distance, usually very deep, and situated in true rock basins—that such lakes as these are absolutely unknown anywhere but in those mountain regions which independent evidence shows to have been subject to enormous and long-continued glaciation. No writer that I am acquainted with has laid sufficient stress on this really

marvelous fact of lake distribution. Prof. Bonney passes it by with the remark that there is a perfect gradation of lakes from the smallest tarns to those of North America and Central Africa; and Mr. Douglas Freshfield says that wherever on the surface of our globe there are heights there must be hollows; and other writers think that lakes are general results of the process of mountain-making. But none of these writers have apparently even noticed the fact that glacier valley lakes have a distinctive character which separates them broadly from the lakes of all non-glaciated countries, and that they are totally absent from such countries.

But besides the mountains which possess true valley lakes, there are a number of ranges which have been glaciated yet do not possess them, and this absence of lakes has been used as an argument against the connection of valley lakes with glaciation. A little examination, however, shows us that these cases greatly strengthen our argument. Comparatively large and deep valley lakes are the result of excessive glaciation, which has occurred only when conditions of latitude, altitude, and moisture combined to produce it. In regions where glaciation was of diminished intensity, from whatever causes, valley lakes diminish in size and number, till at last only tarns are found in moderately glaciated districts. Thus, the Pyrenees were far less severely glaciated than the Alps; they consequently possess no large valley lakes, but numerous small high lakes and tarns. As we go eastward in the Alps, the diminished rain and snowfall led to less severe glaciation, and we find the valley lakes diminish in size and numbers till far east we have only tarns. The Carpathians have no valley lakes, but many tarns. The Caucasus has no lakes and very few tarns, and this may be partly due to the steepness of the valleys, a feature which is, as we shall see, unfavorable to lake formation. In the South Island of New Zealand the lakes are small in the north, but increase in size and number as we go south where the glaciation was more intense. These numerous facts, derived from a survey of the chief mountains of the world, are amply sufficient to show that there must be *some* causal connection between glaciation and these special types of lakes. What the connection is we shall inquire later on.

THE CONDITIONS THAT FAVOR THE PRODUCTION OF LAKES BY ICE EROSION.—Those who oppose the production of lake basins by ice erosion often argue as if the size of the glacier was the only factor and urge that, because there are no lake basins in one valley where large glaciers have been at work, those which exist in another valley where the glaciers were no larger, could not have been produced by them. But this by no means follows, because the production of a lake basin depends on a combination of

favorable conditions. In the first place it is evident that ice erosion to some extent must have taken place along the whole length of the glacier's course, and that in many cases the result might be simply to deepen the valley all along, not quite equally, perhaps, but with no such extreme differences as to produce a lake basin. This would especially be the case if a valley had a considerable downward slope, and was not very unequal in width or in the nature of the rocks forming its floor. The first essential to lake erosion is, therefore, a differential action, caused locally either by increased thickness of the ice, a more open and level valley floor, or a more easily eroded rock, or by any combination of these.

If we look at the valley lakes of our own country and of Switzerland, the first thing that strikes us is their great length and their situation, usually at the lower end of the valley where it emerges from the higher mountains into comparatively low country. Windermere is over ten miles long, Ullswater nearly eight miles, and the larger lakes of Switzerland and North Italy are very much longer. The first essential condition, therefore, was a valley the lower part of which was already nearly level for several miles, and with a considerable width to the base of the mountain slopes. In the non-glaciated districts of our own country, the Dart and the Tamar are examples of rivers which have cut their valleys down nearly to sea-level while still among the hills; and in South Wales the Wye, the Usk, and the Severn have a similar character.

It must always be remembered that glacial erosion is produced by the tremendous vertical pressure of the ice, by its lower strata being thickly loaded with hard rocks frozen into its mass, and by its slow but continuous motion. In the lower part of its course a glacier would be most charged with rocky *débris* in its under strata, since not only would it have been continually breaking off and absorbing, as it were, fresh material during every mile of its onward course, but more and more of its superficial moraines would be ingulfed by crevasses or *moulins*, and be added to the grinding material below. That this was so is proved by the great quantity of stones and grit in the "till," which is thought by Prof. James Geikie to consist, on the average, of as much stony matter as clay, sometimes one material preponderating, sometimes the other. The same thing is indicated by the enormous amount of *débris* often found on the lower parts of large glaciers. The end of the great Tasman Glacier in New Zealand is thus completely hidden for five miles and most of the other glaciers descending from Mount Cook have their extremities similarly buried in *débris*. Dr. Diener found the Milam Glacier in the central Himalayas completely covered with moraine rubbish; and Mr. W. M. Conway states that the lowest twenty miles of the

Hispar Glacier (forty miles long) are "entirely covered with a mantle of moraine." If these glaciers extended to over a hundred miles long, as did the Rhone Glacier when it reached the Lake of Geneva, much of this *débris* would probably have found its way to the bottom, and thus supply the necessary grinding material and the abundant stones of the "till" found everywhere in the tracks of the old glaciers.

Again, although ice is viscous and can slowly change its shape to almost any extent, yet it takes a considerable time to adapt itself to continually changing outlines of the valley bottom. Hence, where great inequalities occur portions of the rocky floor might be bridged over for a considerable space, and where a valley had a narrow V-shaped bottom the subglacial stream might eat away so much of the ice that the glacier might rest wholly on the lateral slopes, and hardly touch the bottom at all. On a tolerably wide and level valley bottom, however, the ice would press with its fullest intensity, and its armature of densely packed stones and rock fragments would groove and grind the rocky floor over every foot of its surface, and with a rate of motion perhaps greater than that of the existing Greenland and Alaskan glaciers, owing to the more southern latitude and therefore higher mean temperature of the soil and the ice. At the same time subglacial streams, forced onward under great hydrostatic pressure, would insinuate themselves into every vacant groove and furrow as each graving tool successively passed on and the one behind it took a slightly different position; and thus the glacial mud, the product of the erosion, would be continually washed away, finally escaping at the lower extremity of the glacier, or in some cases getting embayed in rocky hollows where it might remain permanently as masses of clayey "till," packed with stones and compressed by the weight of the ice to the hardness of rock itself. The continual lubrication of the whole valley floor by water forced onward under pressure, together with the ever-changing form of the under surface of the glacier as it slowly molded itself to the varying contours of the rocks beneath, would greatly facilitate the onward motion. Owing to these changes of form and the great upward pressure of the water in all the hollows to which it gained access, it seems probable that at any one time not more than half the entire bottom surface of the glacier would be in actual contact with the rock, thus greatly reducing the friction; while, as the process of erosion went on, the rock surfaces would become continually smoother and the inequalities less pronounced, so that even when a rock basin had been ground out to a considerable depth the onward motion might be almost as great as at the beginning of the process.

If, now, we consider that the erosion I have attempted to describe

was going on during a large part of the Glacial period, under a weight of ice varying from one to three or four thousand feet in thickness; that the huge grinding tool was at work day and night, winter and summer, century after century, for whatever number of thousands of years we give to the Glacial period; that, as innumerable other facts prove, the ice moved irresistibly over hill and dale, and up slopes far steeper than any formed by the upward slopes of the bottom of our deepest lakes, what is there of impossible, or even of improbable, in the belief that lake basins were produced by such differential erosion? To the ordinary observer it seems impossible that a mountain valley, half a mile wide and bounded by rocky slopes and precipices two or three thousand feet high, can have been formed without any "convulsion of Nature," but merely by the natural agencies he sees still in action—rain and frost, sun and wind—and that the small, rock-encumbered stream now flowing along its bottom can have carried away the whole of the cubic miles of solid rock that once filled up the valley. But the geologist knows that these apparently insignificant forces *have* done the work, through their continuous action always in one direction for thousands or even for millions of years; and, therefore, having before him so many proofs of the eroding power of ice, in planed and rounded rocks, and in the grooves and furrows which are the latest marks left by the ice tool, and bearing in mind the long duration and possibly recurrent phases of the Ice age—to be measured certainly by tens, perhaps by hundreds of thousands of years—he can have little difficulty in accepting the erosion of lake basins as the most satisfactory explanation of their origin.

Objections of Modern Writers considered.—Prof. Bonney and many other writers ask, why lakes are so few though all the chief valleys of the Alps were filled with ice; and why, for instance, there is no great lake in the Dora Baltea Valley, whose glacier produced the great moraines of Ivrea opposite its outlet into the plains of Italy, and which form a chain of hills fifteen miles long and fifteen hundred feet high. The answer, in the case of the Dora Baltea, is not difficult, since it almost certainly has had a series of lake basins at Aosta, Verrex, and other places where the broad, level valley is now filled with alluvial gravel. But the more important point is the extreme narrowness of the lower part of the valley above Donnas and again near its entrance into the valley of the Po. The effect of this would be that the great glacier, probably two thousand feet thick or more, would move rapidly in its upper layers, carrying out its load of stones and *débris* to form the terminal moraine, while the lower strata, choked in the defiles, would move very slowly. And once out in the open valley of the Po, then a great inlet of the warm Medi-

terranean Sea, the ice would rapidly melt away in the water and in the warm, moist atmosphere, and therefore have no tendency to erode a lake basin.

The Lake of Lugano, with its curious radiating arms, is said to be another difficulty. But each of these arms is the outlet of a valley or series of valleys, which were no doubt reduced to nearly level plains by subaërial denudation before the ice began its work. The basin of these valleys comprises about two hundred square miles and the watershed to the north is moderately high; but there can be no doubt that a large overflow from the Como Glacier poured into it; and the difficulty seems to me to be purely imaginary if we simply recognize the fact that an essential preliminary to lake erosion is a pre-existing nearly level valley bottom.

Another difficulty is said to be the frequent presence of islands in the lakes; but here again the answer is easy. The islands, always ground down to *roches moutonnées,* were craggy hills in the pre-existing valleys, and such hills existed because they had for ages resisted the subaërial denudation which had hollowed out the valleys. The same characters of density or toughness that enabled them to resist ordinary denudation, enabled them also, to some extent, to resist destruction by ice erosion; just as the character of the rocks which enabled ordinary denudation to bring them down to a nearly level surface in the valley bottom, also facilitated the ice erosion which converted the level valley floor into a rock basin and, after the ice left it, into a lake.

Every writer brings forward the well-known fact that the ends of glaciers pass over beds of gravel or moraine matter, without destroying or even disturbing it. But there is no reason why they should do more than compress such beds of loose material and roughly level their surfaces. It is the old delusion of a glacier acting like a scoop or plow that leads to the idea that if it can erode rock slowly it must altogether demolish gravel or bowlder clay. But if we turn to the description I have given of how a glacier erodes a rock basin and apply this to its passage over a bed of gravel or bowlder clay, we shall see that in the latter case the erosion would be much more difficult, because each ice-imbedded stone or rock would press into the yielding material, which would close up instantly behind it under pressure of the ice and thus leave no result. Where the subglacial water accumulated, channels would be cut in the gravel or clay, but elsewhere there would probably be no erosion at all. Some writers maintain that the lakes were all filled up with alluvium previous to the Glacial epoch, and that the ice cleared out this incoherent matter; but it is almost certain that no such clearance would have taken place, because the glacier would pass over such a sur-

face, the stones temporarily furrowing it, while the subglacial water would cut for itself one or more deep channels, and there would thus be no water under pressure acting over the whole surface of the basin, which must be so great an aid to erosion in solid rock.

These considerations apply to the equally common objection, that the great masses of bowlder clay left behind by the ice sheet, and over which it must have passed, prove that it could have had little eroding power. The product of the erosion of irregular rock surfaces in an undulating tract of country, where not carried away by water, would necessarily, by the pressure of the ice, be forced into the more or less sheltered or landlocked hollows, thus tending to equalize the surface contours and facilitate the onward motion of the ice. In such hollows it would be pressed and compacted by the weight of the ice, but would be neither eroded nor forced away until, by the continued process of rock erosion, it became exposed to unequal lateral pressure, when it would be gradually removed to some other sheltered hollow, perhaps to again undergo the same process of removal at a later period, and finally rest in the positions in which we find it. During the later stages of the Ice age when, notwithstanding the onward motion of the middle portions of the glacier, the lower portion was melting away both above and below, and the terminal ice cliff was permanently retreating, almost the whole of the eroded matter, except what was carried away by the subglacial torrents, would remain behind; and it is this final product of glacial erosion that forms the huge deposits of bowlder clay which encumber the surface of the lowlands in most highly glaciated countries. When, however, the moving ice changed its direction, as it often did, during the varying phases of the Ice age, it sometimes acted most energetically in crushing, dragging, and contorting both the bowlder clay and other superficial beds, often causing the wildest confusion in the deposits and sometimes imbedding huge sheets of Tertiary strata or chalk in the midst of the bowlder clay. But this is a very different mode of action from that by which hard rocks are ground down or lake basins eroded.

In reply to the continual assertions of Prof. Bonney, and of most of the Alpine explorers, that the action of glaciers is entirely superficial, and that they actually preserve the surfaces they cover from denudation, a few facts may be here given. From a large number of gaugings by Dollfus-Ausset, Dr. Penck has calculated that the solid matter in the torrent which issues from the Aar Glacier annually amounts to six hundred and thirty-eight cubic metres for each square kilometre of the surface of the glacier, a quantity sufficient to lower the bed of the glacier one metre in sixteen hundred and sixty-six years, or one foot in five hundred and

five years; and the same writers calculate that the same amount of erosion in a valley by water alone would require two and a half times as long.* Other writers have made estimates less favorable to ice as an agent of erosion; but even if the amount annually be but small, the cumulative effect was undoubtedly very great in the case of the enormous glaciers of the Ice age. The very wide areas covered with bowlder clay and drift in North America, and its great average depth, have already been referred to in my previous article (Popular Science Monthly, April, 1894, p. 782); but a still more striking estimate has been made of the amount of rock *débris* in northern Europe which can be traced to Scandinavia. Dr. Amund Helland states that about eight hundred thousand square miles are covered with such drift to an average depth of one hundred and fifty feet, of which about one hundred feet are of Scandinavian origin, the remainder being local. The area of Scandinavia and Finland, from which this *débris* has been derived, is very much less than the area over which it is distributed, so that to produce it an amount equal to an average thickness of two hundred and fifty-five feet must have been removed from those countries. To this must be added the amount which has gone into the Baltic and North Seas, and also that which has been carried away by rain and rivers since the Ice age passed away, and yet further, the enormous amount that still remains on the lowlands of Scandinavia, and we shall then arrive at an amount probably twice as great as the above estimate, that is, something like five hundred feet as the average amount of ice erosion of Scandinavia during the Glacial period.† Now, unless this estimate is wildly and extravagantly erroneous—and Prof. Geikie adopts it as *prima facie* not extravagant—we have an amount of ice erosion so enormous as to put completely out of court all the allegations of those who attempt to minimize it as a mere smoothing off of sharp angles and rugged surfaces. I am not aware that Prof. Bonney denies the Scandinavian origin of the greater part of the northern drift, and unless he can show that its quantity is something like a fiftieth part only of the estimate of Dr. Helland, I can not understand how he can still maintain that the glaciers and ice-sheets of the Ice age were agents of abrasion, not of erosion, and that they were therefore impotent to grind away the comparatively small amount of rock removed, under the most favorable conditions, from the basins of the valley lakes whose origin we are discussing.—*Fortnightly Review.*

[*To be continued.*]

* Falsan, La Période Glaciaire, p. 90.

† Fragments of Earth Lore, by James Geikie, F. R. S., 1893, p. 167.

CAUSE AND EFFECT IN EDUCATION.

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I DO not know when the intellectual life is born. If we consult our own very different and individual experiences we would reach a variety of answers. But I shall at least express the experience of a large body of people in saying that this intellectual birth begins when for the first time we apprehend the principle of causation.

In any age there are but few who have attained the intellectual life. The vast majority of the race are still absorbed with the vegetative and animal functions of life. One would say that the birth of the spirit is not yet. Even among those called enlightened the major part merely assent to the principle of causation. They can not be said to apprehend it as an experience of their own intelligence. If you propound the principle to average men and women they will unhesitatingly agree with you. It takes no great cleverness to see that a denial would mean an impossible contradiction. In the sequence of events, causes are followed by adequate and commensurate effects; back of all effects are adequate and commensurate causes. This does very well as an abstract sentiment. But in the next comment which these good people make upon human affairs, it is more than probable that their denial of causation will be quite as direct and explicit as if expressed in so many words. And this is notably the case if the comment be upon those affairs which involve long-standing traditions, as when the talk turns upon political or social or religious issues.

The difficulty of being consistent is a great difficulty. The ability to be consistent is a proper test of intellectual progress. A great advance has been made when the beliefs in one department of thought are not entirely contradicted and neutralized by the beliefs in another department; when even a small residue of positive philosophy remains; when our science does not contradict our religion, and our religion our politics, and our politics our sociology.

How shall one attain even a moderate degree of reason? It is a large task to make the beliefs in any one bundle harmonize. It is a still greater task to make the bundles themselves harmonize with one another. In the autobiography of John Stuart Mill we have the record of such an attempt, and I know of no book in the language, which so stimulates one's desire to undertake a similar task.

Turning now from the workers to their work, the same prin-

ciple will serve as an adequate test of progress. Any branch of knowledge becomes a science only when the relation between cause and effect is rigidly established, and the capricious and accidental are as rigidly eliminated. Comte found his test of science in the power of prediction. There is no science, unless under certain given conditions we can say precisely what will happen. But this, I take it, is only another way of saying the same thing: we can predict only when we have perceived the causal relations.

The most common affairs of life have not yet been reduced in practice to a science. Bread-making, for example, is still a black art. You put flour and water and yeast and salt and lard together, and do certain things to it, and then trust to the gods to make it into bread. Sometimes they do and sometimes they don't. Sometimes you have good bread and more often you don't. Yet I once met a man, an ex-college professor, who said that he always had good bread. His recipe was simple: he made the conditions invariable and the results were likewise invariable. We have all heard of the lady who, when her servant was out, put wood and paper and coal together, applied a match, and then went upstairs and prayed that she might have a fire.

Practically we do not disapprove of this condition of affairs. For the most part, it amuses us.

But the less domestic sciences afford better illustrations of the realization of the principle. In the hands of Kepler, for instance, astronomy failed to be a science. With wonderful skill he applied his knowledge of conic sections to the motions of the planets. Yet he could offer no better explanation of these motions than the suggestion that each planet was the chariot of an indwelling, guiding spirit. We could predict nothing of these imaginary charioteers, for the laws which might be presumed to govern them were quite beyond the limits of investigation. But with the introduction of the conception of universal gravitation, the study of astronomy took rank as a recognized science, and its observed phenomena were reducible to an orderly sequence of cause and effect. It is true that gravitation itself remains as profound a mystery as the charioteers of Kepler, and in substituting the one for the other we have not explained the universe. But we never hoped to do that. The superiority of gravitation lies in this, that it is the cause of uniform and measurable effects. Under Kepler's conception of things, the perturbations of Uranus might be ascribed to a little caprice on the part of the charioteer. Under Newton's conception such a disposition of the irregularities would be impossible. They could result only from the attraction of a definite amount of matter acting at a definite distance. When Adams and Leverrier had completed their calculations, Dr. Galle

knew exactly where to point his great telescope, and, as we all know, it pointed to Neptune.

It was the same with geology. Sir Charles Lyell substituted for the unimaginable cataclysms of the older geologists the slow and simple operations of Nature's present forces. It was his work which changed geology from a wild dream into an accurate science, and to-day we hold this principle of causation as the check and test of all geological speculations.

The science of chemistry was born when the principle of the conservation of matter became established, and men stood face to face with the necessary relation between cause and effect; when they realized their own inability to bring matter out of nothingness, or to make it pass into nothingness again. Similarly, physics, as a science, came only with the recognition of the principles of the conservation of energy and the correlation of forces. It is difficult for us, standing on the vantage ground of the present, to realize into what an abyss we should suddenly plunge if we lost sight for one moment of these gains and passed into a world of thought in which energy came and went and matter appeared and disappeared. It would practically be a world of insanities.

Almost in our own generation we have seen the birth of the science of biology, and we all remember very vividly the bitter pain of its birth. As a branch of study, it has existed from the very earliest days when man first began to observe animated Nature; but it remained a body of isolated facts until the work of Darwin and Wallace established the causal relations involved in evolution, and suggested the mode by which this process of unfolding had been brought about.

It would be very easy to enlarge these illustrations in what we call the "natural" sciences, but it is hardly necessary. The point is probably established.

In those branches of inquiry which have to do with human rather than with purely physical activities, we shall find precisely the same thing; but in this case their history is so complex that the recognition of the principle of causation, and its application to human affairs, have been correspondingly slower. Even now it is far from complete. Nevertheless, in this study of the human spirit, we have all along been blindly trying to establish the principle of cause and effect. In the half-science which has grown out of this attempt, the failure has come, not from a wrong end in mind—and this is to be particularly noted—but rather from the establishment of fictitious causal relationships. In the complex operations of the human spirit we have observed definite results; we have sought for causes; we have not been wise enough to find them; but we have found something which we mistook for causes, and so we have built up a system founded on false re-

lationships. The mistake is difficult to rectify. These imaginary causes must first be swept away. The true science comes only when the true and adequate cause is discovered.

We are witnessing to-day the rehabilitation of the sciences of the human spirit. In all of them the reforming process is the same. It is the mending of the old mistake; the getting rid of the fictitious causations, and the search for the true ones. Thus, for example, the fertile thought in modern sociology is the growing recognition of the fact that national characteristics are the direct outgrowth of the material conditions surrounding the nation—the climate, the soil, the food. The evil of intemperance is being met and vanquished on the same ground, not by prohibitions and pledges, but by the substitution of such a rational diet and such rational life conditions that an exhausted physical system will no longer crave the false stimulus of intoxicants. If a young man drinks to excess we no longer put the blame upon the devil, although in giving up this cause we have certainly dispensed with a great convenience. We put the blame nearer home. The careful housekeeper, overbusy with much scrubbing, has had something to do with it, if in her eager pursuit of dust she has forgotten to provide wholesome, nutritious food for the vigorous, healthy organisms committed to her charge. The home conditions have had something to do with it if they have offered attractions so meager as to be quite outweighed by the anæsthesia of drunkenness.

This modern search after true causation is merciless in its operation. It is a two-edged sword. It is tracing home the source of social distempers to men and women who have hitherto been complacently patting themselves upon the back and putting the blame upon the world, the devil, God, Providence—in a word, upon anything rather than upon their own ignorance.

Among the many activities concerning themselves with the welfare of the human spirit, there is none more complex, more difficult, or more important than that activity which we sum up under the name of education; but the history of its growth is much the same history as that of the sciences, "natural" and "human," which we have just been sketching. If it is to become a science, it is to become one by precisely the same process as these have done—that is to say, by the establishment within itself of true causal relations.

In all of this, one is but the chronicler of the obvious, and says nothing that is new. But probably the verities are mostly old. It is only their restatement that is new. Let us be honest. Let us acknowledge that what we most need is, not so much any fresh accession of truth, as a more sincere and persistent effort to live up to such measure of it as we have.

And yet this very obvious thing has not been done. One can not honestly say that the education of to-day rests upon a scientific basis. It seems to us absurd now that Kepler should have referred the planetary motions to an indwelling will. But we are doing things even more absurd in the name of education. We observe tendencies in children: we refer them to false causes. We desire a certain development: we set in motion the wrong machinery. In a word, as scientists we are causationists; as educators we are not.

Now, what is to be done about it? Modern educators are for the most part sincere, enthusiastic, devoted. Even to those who teach simply for the salary, there must come occasionally an altruistic thrill. Why then do we fail so dismally? Why are we all so blind?

It is easier to ask questions than to answer them; to declare one's self a sinner than to become a saint. But the world is old. It has met many sorrows. We ought from these to be able to learn some lessons. We ought to be able to reach some fertile thought capable of transforming education into a science.

Few problems have had greater play of thought about them than this very problem of education, and it has been thought of a high character. The various lines which this thought has taken are to be found in the histories of education. It is noticeable in glancing over this curious history that all lines converge in this one point, that each system of education which they represent is the somewhat retarded reflection of the *Zeitgeist*—the belated product of the great time-spirit of the age in which they happened to be born. Resting, as education does, upon all the other sciences, it is inevitable that its fruition should follow theirs. With religion and ethics and sociology and biology in a state of incoherence and empiricism, it was manifestly impossible for education to be rational. It was first necessary that the foundation sciences should be reduced to order, and the sequence of cause and effect established within their own borders. This has been done in part. It is the peculiar glory of these closing years of the nineteenth century that they have witnessed a unification of knowledge such as previous ages had not the power even to dream of. These many sciences upon which education rests have been shown to be but so many manifestations of one science, and the phenomena which they study but the operations of one law. And this law expresses the orderly sequence of the universe, the inviolable following of cause and effect, the exclusion of exterior, unmeasurable agencies, the uniform unfolding of the present out of the past—in a word, it is the great law of evolution. The system of education which is the proper flower and fruit of this

accumulated science is clearly a system which proceeds upon this universal principle of development.

We have said that the reflection of the time-spirit which education represents is always and necessarily a somewhat retarded image. It follows the time-spirit. It can not precede it. But were this all, the problem of education would be vastly easier than at present. Fallen as we are upon a scientific age, it would be a comfort to believe that the image of it shown in education would surely conform to it, however slowly. But unfortunately the plate upon which this reflection is thrown is far from free. It bears already the deep impressions of many previous images. At any moment our education reflects not only the living *Zeitgeist*, but also, and even more clearly, the dead standards of a long past. It is seldom that a man arises among us who has sufficiently clear vision to distinguish these several images and apply the upper one to the needs of childhood. It is comparatively easy to refute a sophistry with a new face. It is tremendously difficult to escape the power of a sophistry to which you have been born, and in the presence of whose illogic you have always lived. It takes genius to escape.

But suppose now for one brief moment that we could apply a sponge to this complex plate of ours—not from the front, for that would remove the image we most wish to preserve; but from the back, removing image after image until we came to the last and uppermost—what do you think we should remove, and what let stand, in our current education? I think we should erase much and leave but little. Let us see.

The human infant is a much less complex thing than we are wont to think. It is plastic and general; for the most part a mere bundle of possibilities. And we stand to it in the relation of Fate or Destiny. We have given to us a tiny organism with little individual will or intelligence. The influences to which we subject this organism constitute the educative process.

There are two elements to be considered. First of all, there is wrapped up in this tiny ball of organized matter an inherent tendency more inexorable than the predestination taught by Calvin. We call it heredity. It is the gift, for good or ill, of fathers and great-grandfathers, of mothers and great-grandmothers, for many generations back. The fairy godmothers who come in the story book to every child's christening represent a scientific fact. The talents they bestow, the fatal limitations they inflict, are not by chance. They are the qualities of ancestry.

A system of education neglecting this element of heredity neglects a determining cause, and is fundamentally unscientific. But it is an element largely beyond the control of the teacher. All he can do is to develop these germs, or discourage them, as

heredity seems good or bad. Even in this very moderate function he blunders, for the most part, terribly.

The second element is the one with which we have practically to deal. It includes all post-natal influences. In science we call it environment.

It is a long-standing debate as to which of these elements is the stronger. We need not enter the controversy. The balance of present evidence seems to support that view of the matter which gives the greater influence to environment. In this lies the hope of the educator. We mean to get the best of the dead great-grandmother. Mr. Fiske has pointed out that in the increased helplessness of the human infant, in its greater freedom from inborn instincts, in the lengthening days of the plastic period of infancy are to be found the possibilities of a far greater individual advance.

This, then, is the problem set before us as educators—so to shape these influences that the developing human spirit may approach perfection. It is not a new problem. It was before the Greeks. It was before the men of the middle ages. It has been constantly before our own people. But it has never been very satisfactorily solved.

The extent of our failure can be better realized when we remember that nearly all educational reforms have been forced upon the schools from without. They originated with men and women who were so fortunate as to escape the pedagogical blight. When we remember further that the men of mark in the great world of action and creative thought have either been educated in an irregular fashion, or, if they have gone to the academies and colleges, have never taken the courses too seriously, these facts are significant. They mean that education has too often been a thwarting of the spirit, an attempt to fit a square plug into a round hole, a pressure, a dead weight, rather than an unfolding. They mean, in short, that education has seldom, in practice at least, been reduced to a science.

We fail as Ptolemy failed, as Kepler failed, as the alchemists failed. We fail because we do not observe the true sequence of cause and effect in the life of the child. We shall succeed when we abandon our educational nostrums, our tonics, our pills, our philosopher's stones for turning ignorance into knowledge, our short-cut methods of salvation for making bad into good. We shall transform education into a science and educators into scientists when we give up these off-hand remedies, these false views of causal relationships, and come to recognize the simple fact that the child is an organism, and that the processes of growth and education must conform to the laws of organisms. We must part company with that fatal duality which separates body and spirit.

We must look upon the child as a unit. We must see in it an organism which includes both body and spirit, an integer. Then we shall substitute true causation for false causation. To do this, will be to follow in the footsteps of Newton, to write the Principia for education.

To make a good telescopic lens we must have glass of a certain quality, high refractive power, freedom from flaws, perfect transparency. Then we must carefully fashion it into a certain prescribed form. How utterly stupid it would be for us to spend all our time and energy upon one half of the problem—the fashioning of the lens—and neglect the quality of the material! We can imagine no one insane enough to do such a thing. Yet in education we are guilty of this very insanity. It is no wonder that the result so often fails to disclose heaven.

Another illustration. Carbonic-acid gas, ammonia, and water vapor constitute the chief food of plants. But you may surround a plant with just such an atmosphere, and yet get little growth if the soil be unsuitable, and the vivifying sunshine be not there to transmute this food into vegetable fiber. I often stand in our crowded schoolrooms with the feeling that we have provided an atmosphere rich in the materials of knowledge—possibly over-rich—but that we have not seen to the root of the matter in trying to meliorate the life conditions of the child; and particularly that there is lacking the needed sunshine of a joyous, wholesome spirit to assimilate this food, and turn it into healthful human growth.

If a boy be up late at night; if he be routed out of bed early on the following morning, before the strong sleep of youth has spent itself; if he be flurried with little household cares, and the inconveniences of long transportation, is it a wonder that when at last he reaches the school, out of breath, and just in time to hear the morning lesson, we can do little with him? The marvel is that we should expect to. He had much better stay at home. Fond parents tell it of their children, and priggish children tell it of themselves, that they have not missed a single day at school in eight or nine or some other weary waste of years. There is no merit in this. The question is, What spirit did they take along, and what did the school profit them after they got there?

The life of an organism consists of nutrition, of growth, and of reproduction.

How often do we remember these cardinal facts in handling the human organism? The food of school children is of the most haphazard character; their growth, an accidental factor, and the holy mystery of fatherhood and motherhood too delicate a matter to mention to them. We err very grievously against the helplessness of childhood and youth in thus willfully neglecting the

known elements in their development, and turning so persistently to imaginary and fictitious causes. We are practically denying the principle of causation.

One may not be willing to say that the brain secretes thought as the liver secretes bile; but whatever theory of the origin and nature of the human spirit we may entertain, it must be admitted that the brain is its tool, and to have a wholesome manifestation requires a wholesome instrument. One need not be frightened—this is not materialism. I do not want the child to be merely a wholesome kitten—a beautiful, soulless Antinous. Let us think of him as a unit. When we say food, we have in mind ideas as well as oatmeal. When we say growth, we have in mind increasing perception as well as increasing stature. When we say reproduction, we have in mind the creative activities of the artist spirit, as well as the function of parenthood. But these things go together. It is neither an animal nor a spirit which presents itself at our door and submits to be educated. It is a monistic child.

We shall never have a scientific system of education so long as we persist in considering only a part of the child's day, and only the exterior aspect of his life. It is useless to argue that these matters belong to the province of parents, and not of teachers, for we all know that they are sadly neglected. The day school can not succeed without the co-operation of the home. It is rarely forthcoming. The average American parent will make heroic sacrifices to give his children what he is pleased to call an education. To him, this means sending them to school—five hours out of twenty-four, five days out of seven. In this he only illustrates his supreme faith in machinery. Under what influences do the children come? With what other children do they associate? What happens to them for the rest of the time?

Who asks these questions?

Nobody.

Who knows the answers?

Nobody.

We fail, then, so lamentably as teachers, not because we are altogether unwise, or because our methods are altogether bad, but very largely because we have deficient organisms to work upon. We are stupidly trying to make bricks without straw. We are trying to educate without employing the means by which alone education can be accomplished.

A curious case has recently come to my notice of a little English girl who suddenly developed a propensity for stealing. Her parents were naturally much mortified. The child herself was very unhappy, for she felt keenly the withdrawal of affection on all sides. In despair she was taken up to London, to a child specialist. He examined her carefully, inquired into her manner of

life, and finally pronounced the difficulty to be anæmia. He ordered her to be put to bed and given as many sweets as she would eat. In a short time the child regained her health, and with it her normal attitude toward life.

It is not probable that all moral disorders could be cured by so simple a prescription as sugar, but it is probable that the removal of organic disorders would remove many of their concomitants—moral disorders.

We close our eyes to this. The reflected image of our scientific *Zeitgeist* is faint compared to the deep-set images of a dead time-spirit. These images have their home in the traditions and superstitions of society. They are the reflection of ignorance, not of knowledge. They belong to a metaphysical rather than to an experimental age.

What are some of these images?

Baffling the clear recognition of cause and effect in the life of the child, there still lingers, and lingers persistently, that monstrous fiction of a diseased imagination which men call sin. It is the image reflected from a theological as opposed to a religious age. It is an obstacle in very truth, for it turns us away from causal terms to a false nomenclature and a false treatment. We say that a boy is bad when we ought to say that his life conditions are unfavorable; that his parents and teachers are unwise. It is difficult to search out the true cause of wrong action. It is easy to call it sin. This is a stubborn image. It persists, for it has back of it immense vested interests. We have in our midst a vast organization which rests its whole excuse for being upon the reality of sin. Its sole function is to circumvent this enemy, and conduct man to God and heaven. It would be disorganizing to admit that in all this it is fighting a poor human fetich, whose shadow obscures from humanity the gracious face of the Eternal. Yet to abandon this nightmare would simply be to return to the pure teaching of Socrates. The monstrous entity of sin had for him no real existence. He found in the world vast ignorance, and he fought it. Virtue he regarded as the fruit of knowledge, and he cultivated it.

Another hideous image comes to us from a vulgar and ascetic age. It regards the uncovered human body as an object of shame. With such immodest ideas of modesty we attempt the development of an organism which we keep studiously out of sight. Little Margaret is very picturesque in her quaint gown and big hat. They conceal the fact that her poor little body is stunted and undeveloped, and will but ill withstand the emotions and functions of womanhood. Brother Jack is also a lively figure in bright kilt skirt and velvet jacket. His neck is thin, but it is surrounded by a very broad linen collar. We look at that

and find him charming. His little legs are slender as broomsticks, but they are in thick black hose, and the red kilt attracts the eye. We look at that and are satisfied. He is active and noisy. We take it for granted that he is getting on finely. Were he in the bath-tub, we should think otherwise. Later, Jack goes to college. He breaks down. His mother says it is overwork. But this is not the truth. The truth is that he has not the brain power to cope with normal intellectual tasks. The fault is elsewhere than with the curriculum. In all this, the image cast by prudery makes us horribly unscientific. Worse still, it makes us hopelessly vulgar.

These are but two out of a large and bad company of images which to-day obscure the reflection of science in education. They make difficult the recognition of the simple fact that the child is an organic unity; and they make practically impossible the development of any system of education based upon this truth. So long as we allow this obscurity, and persist in this blindness, we shall have no science of education, however many schoolhouses we may build, for we shall be steadily doing violence to a principle which may not be violated—the sequence of cause and effect.

ECONOMIC USES OF NON-EDIBLE FISH.

BY ROBERT F. WALSH.

FEW people are aware of the important uses to which non-edible fishes can be put, and fewer still have any idea of the thousands of millions of such fishes that are to be found along the coast of the United States. What some of these uses are will be learned from the following statement of Prof. G. Brown Goode, in his article on American Menhaden in Part V of the Report of the United States Commissioner of Fish and Fisheries for 1887. He says: "Millions of pounds of fish not fit for human food are allowed every year to escape from nets into the sea, which, if saved and rightly utilized, would be worth untold sums for fertilizers and feeding purposes. Of the fish saved and used for fertilizers, a large portion is ill prepared." And he continues, "A large part of that which is well made is exported to Europe, where its value is better understood and its use is more rational and profitable." Following these statements Prof. Goode says that "the total loss to our agriculture from all these sources is not capable of accurate computation, but certainly amounts to hundreds of thousands and doubtless to millions of dollars annually." But there are other uses to which these millions of fishes can be profitably applied; so that the value of our available

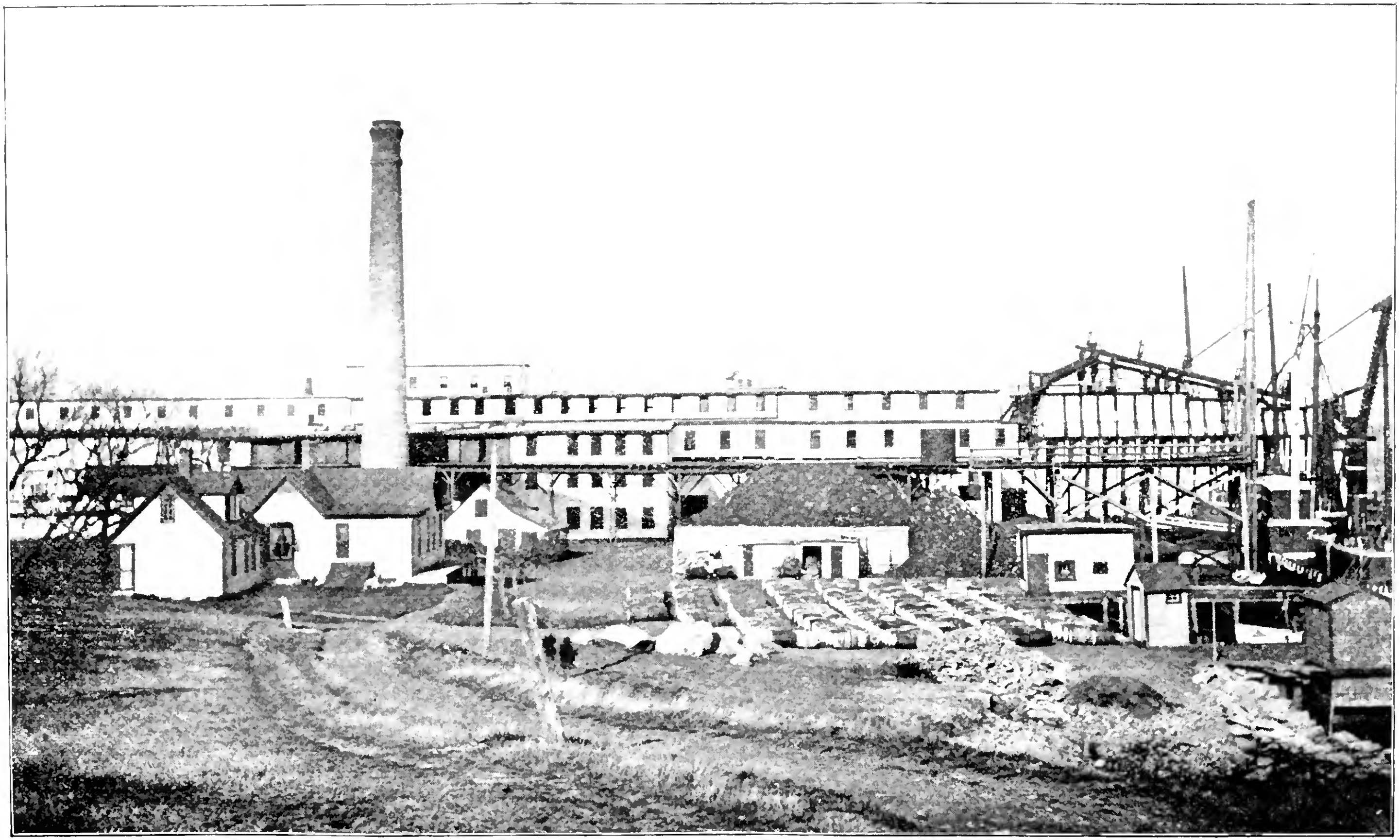


Fig. 1.—Part of a Menhaden Oil and Guano Factory at Tiverton, R. I.

non-edible fish supply probably exceeds that of those fishes which are used for food.

About twenty years ago a beginning was made in utilizing non-edible fish; but, from one cause or other—prohibitive State legislation, want of knowledge as to the best ways of obtaining fish products, and various other less important impediments—the industry is still far from that position of commercial and industrial importance to which it is justly entitled. But, notwithstanding the impediments to which I have referred, and although the operations of the factories engaged in the utilization of non-edible fishes are confined to the production of oil and guano from menhaden, in the year when Prof. Goode made the estimate above quoted over eight hundred thousand dollars' worth of crude and dried guano was produced, and 2,426,589 gallons of oil were obtained.

Bearing these figures in mind, and remembering that Prof. Baird estimated that "twelve hundred million millions" of menhaden are destroyed annually by bluefish—during four months in the summer and fall—and that this destruction is imperceptible in the myriads of these fishes which abound on the coast, it is apparent that, under favorable conditions, the value of menhaden to the commerce of the country could easily be developed to an extent that would at least equal the combined values of all our food fisheries.

It would be extremely difficult to fix the time when fish was first employed for fertilizing. We are assured, however, that long before the advent of Europeans on this continent, the Indians used menhaden for raising agricultural produce. The early colonists imitated the natives; and in 1632 Thomas Morton, of Virginia, wrote: "There is a fish (by some called shadds, by some allizes) that at the spring of the yeare pass up the river to spawn in the ponds, and are taken in such multitudes . . . that the inhabitants doung their ground with them." Eleven years previous to Morton's record Governor Bradford tells how "in April, 1621," the colonists began to sow corn, "in which service Squanto (an Indian) stood them in good stead, showing them both y[e] manner how to set it and after how to dress & tend it. Also he tould them axcepte they got fish & set with it (in these old grounds) it would come to nothing; and he showed them y[t] in y[e] midle of Aprill they should have store enough come up y[e] brooke by which they begane to build, and taught them how to take it."

Still later, and just one hundred years ago, in the Transactions of the Society for the Promotion of Agriculture, Arts, and Manufactures, instituted in the State of New York, Hon. Ezra L'Hommedieu says: "Experiments made by using the fish called menhaden, or mossbunkers, as a manure have succeeded beyond

expectation, and will likely become a source of wealth to farmers living on such parts of the seacoasts where they can be taken with ease and in great abundance. These fish abound with oil and blood more than any other kind of their size. They are not used for food, except by negroes in the West India Islands." This is absolute proof of the recognition of the value of men-

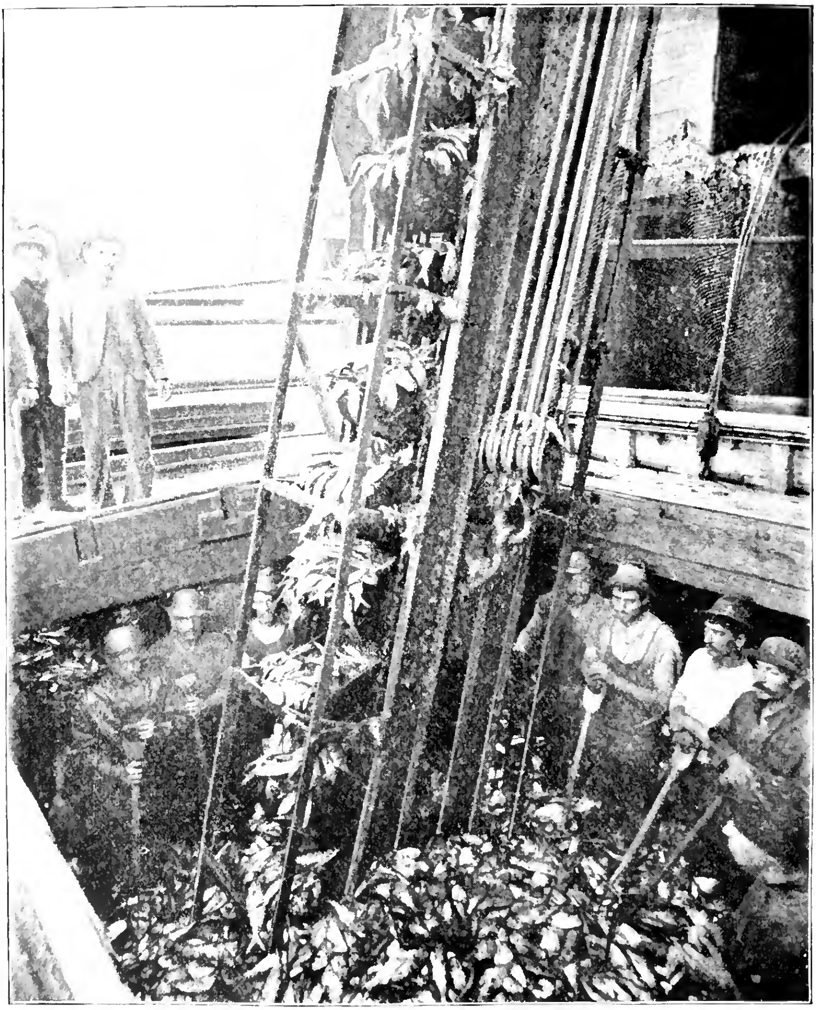


Fig. 2.—Discharging a Cargo of Fish by Traveling Buckets.

haden for fertilizing purposes one, two, and nearly three centuries ago. But we have even stronger early testimony in the letter of President Dwight, of Yale College, who in 1804 writes: "No manure is so cheap as this, . . . none is so rich, and few so lasting. Its effects on vegetation are prodigious. Lands which

heretofore have scarcely yielded ten bushels of wheat by the acre, are said, when, dressed with whitefish (menhaden), to have yielded forty. . . . Such, upon the whole, have been their numbers, and such the ease with which they have been obtained, that lands in the neighborhood of productive fisheries are declared to have risen, within a few years, to three, four, and, in some cases, to six times their former value."

I shall give only one other authority for the use of fish and fish refuse as a fertilizer. In 1853 Mr. Ker B. Hamilton, Governor of Newfoundland, said: "In this island the manure universally applied to the soil is fish, consisting of the superabundant herrings and caplins in the process of decomposition, and generally without any earthy admixture; and the heads, bones, and entrails of codfish." From other sources we learn that in Norway, France, Japan, and in the British Islands, fish has been used, in its raw state, for fertilizing purposes, whenever it was found in great abundance.

Although we have evidence in the olden writings that the oil obtained from various fishes was used for lighting and other purposes, fish oil was practically unknown in commerce until about fifty years ago. Since then there have arisen hundreds of purposes to which it is daily applied.

The origin of the present menhaden industry was the discovery of an old lady, named Mrs. John Bartlett, of Blue Hill, Maine, who in 1850, when boiling some fish for her chickens, observed a thin scum of oil upon the surface of the water. "Some of this she bottled, and when on a visit to Boston soon after carried samples to Mr. E. B. Phillips, one of the leading oil merchants of that city, who encouraged her to bring more. The following year the Bartlett family industriously plied their gill nets and sent to market thirteen barrels of oil, for which they were paid at the rate of eleven dollars per barrel." In the following year this family made one hundred barrels. Then, the value of menhaden oil having become recognized, many oil presses—of a more or less imperfect construction—were established along the coast, and the industry developed so rapidly that within twenty years the yield of menhaden oil exceeded that of the whale (from the American fisheries). It now exceeds the aggregate of all the whale, seal, and cod oil made in the United States, and Prof. Brown Goode says, "As a source of oil, the menhaden is of more importance than any other marine animal."

The prime object of the first factories established for utilizing menhaden was the production of oil—the residuum, or "scrap," as the pressed fish is called, being looked upon as a secondary consideration. Nevertheless, this by-product was of equal worth, and in some years has exceeded in value the output of oil. This

"scrap" is a much better fertilizer than the whole fish; for the undesirable element—the oil, which "clogged the earth and made it unfit for tillage"—has been removed, and the "scrap" is left, containing plant food in proportions far exceeding those of any known natural fertilizer.

The process of extracting the oil from the menhaden is very simple. When the fish is delivered at the factory it is immediately placed in large iron tanks, containing about a foot deep of water. Heat is then applied until the mass begins to simmer, when the heat is turned off. In this way the fish is thoroughly steamed, and the oil cells are more or less separated from the flesh, so that the oil can be readily and thoroughly released in the presses. Often, when the fish is rich in oil, a considerable quantity exudes during the steaming process. This is drawn off from the top of the simmering mass and runs in troughs to the oil tank.

After the steaming, the fish is placed in "curbs" (circular vessels having perforated bottoms) and rolled to the oil presses. Here the oil is released by hydraulic pressure, and the remainder is simply the nitrogenous part of the fish, which is called "scrap."

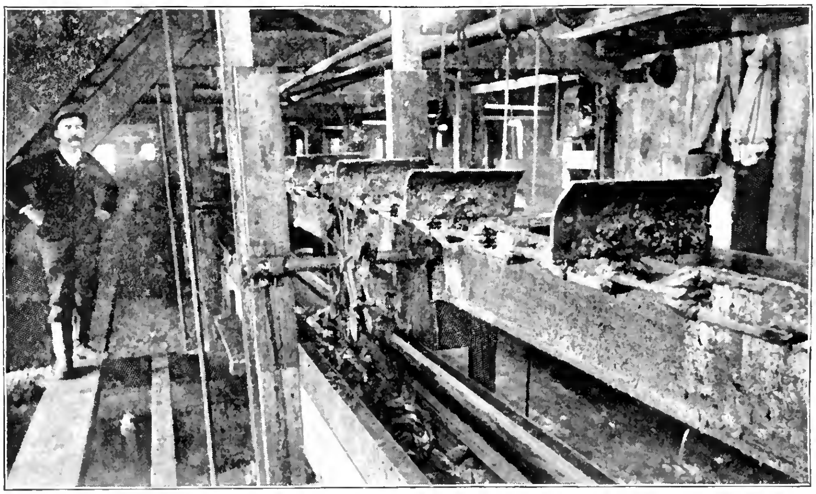


Fig. 3.—Steaming the Fish.

In the factories of the United States Menhaden Oil and Guano Association the oil is not rectified; it is expressed in the simple manner that I have explained, and then shipped to the different oil merchants and refineries of the United States and Europe.

The preparation of the scrap, or fish guano, is also very simple. After the oil is released, the solid matter is taken to the drying boards—a large field covered with closely fitting grooved and tongued flooring—upon which it is spread to dry. At Tiverton

the drying field comprises nearly twenty acres. From first to last the greatest care is taken that no foreign substance shall become mixed with it. When it is sufficiently dry it is bagged for transportation, either to the manufacturer of artificial fertilizers or direct to the farmer. The total quantity of menhaden "scrap" manufactured during the nineteen years from 1874 to 1892 inclusive was 912,467 tons (dry and acid), and the amount made from other non-edible fishes and waste fish in the United States is esti-

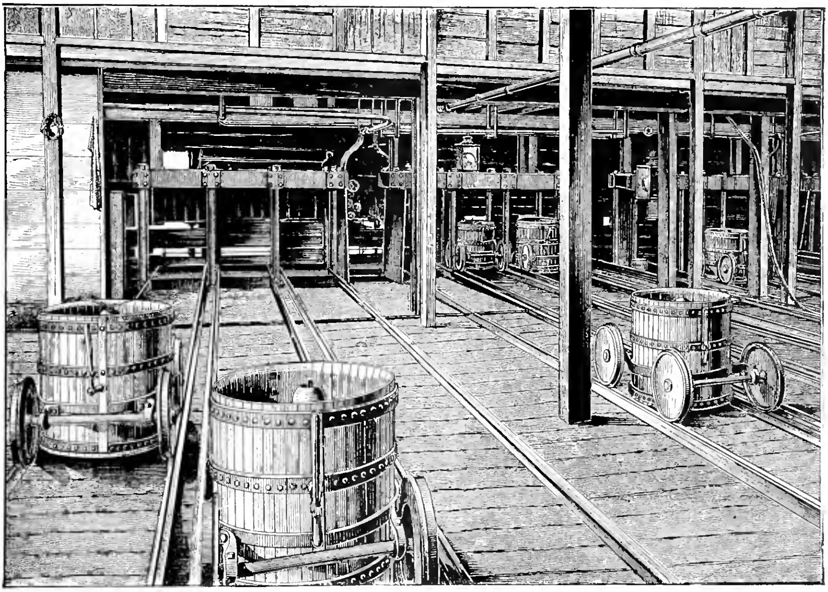


Fig. 4.—Interior of Curb Room in Factory, showing the Iron Cylinders in which the Scrap is Pressed.

mated at 150,000 tons. By analysis, the average percentage of nitrogen was found to be eight per cent in the dry scrap and six per cent in the acid, while the acid guano contained four per cent of phosphoric acid, and the dry seven per cent. This gives us a total plant food (nitrogen and phosphoric acid) of 135,000 tons, or about $31,000,000 worth at the present rate fixed by the New England experiment stations.

The average price at which this fish guano was sold was fifteen dollars per ton for the acid scrap and twenty-five dollars for the dry. The guano from the Peruvian deposits which has been imported into this country during the past thirty years contained from four to eight per cent of nitrogen, with about an equal percentage of phosphoric acid, and millions of dollars have been paid for it at the rate of from forty-five dollars to eighty dollars per ton. Why such a great disproportion exists in the prices seems

to be unanswerable, and it will seem still stranger in view of the fact that the fishermen of Lofoden, one of the Norwegian Islands, should readily get forty-five dollars per ton for dry scrap made by them from cod refuse. These apparently anomalous conditions can, however, be partially accounted for from the facts that the Peruvian guano is sold in a finely powdered state, and perfectly dry, and the Lofoden islanders grind their scrap after drying it upon the rocks by the sun's heat. In this condition the nitrogen is more quickly assimilated, and the effects more speedily appreciated by the growing crops. But this process could easily be applied to the American product, and I have no doubt but that ground or machine desiccated fish guano will form one of the chief features of our manufacturers as soon as favorable or rather just legislation will enable the manufacturers to calculate upon more certain supplies.

Mr. William Bowker, of the Massachusetts Board of Agriculture, estimates that the 135,000 tons of plant food, referred to earlier, contained more than sufficient phosphoric acid and enough nitrogen for "3,200,000 acres of corn, of fifty bushels each, or 7,000,000 acres of potatoes of one hundred bushels each."

Let us now glance at the figures of the menhaden oil production. From 1874 to 1892, inclusive, the quantity of oil expressed from menhaden amounted to over 46,000,000 gallons—about 165,000 tons. This was sold for prices varying according to the abundance of the fish, from fifteen to twenty-one cents per gallon in the seasons of 1885, 1886, and 1887, to thirty-five cents in 1879, and forty in 1881; the price being thirty-two to thirty-three cents during the past year (1893); so that the average price was about thirty cents for these 46,000,000 gallons, or $13,800,000 for the oil product of the menhaden fisheries for nineteen years—equivalent to $725,000 per annum. Add to this the average yearly value of the acid and dry guano, as computed by Mr. Bowker, and we find that the menhaden industry has enriched the country by $2,360,000 annually since 1873.

The oil has been used largely in tanning leather, and as the basis for many oil paints and varnishes, while a great deal of it is consumed for lighting purposes in our mines and elsewhere. The quantity of oil annually exported is also very large, and the demand for it is so great that markets could readily be obtained for ten times the quantity. These are startling facts, and facts that deserve most studious consideration. We have been reaping over two million dollars' worth of products from menhaden and other non-edible fish annually, despite repressive legislation in three of the States in whose waters those fishes abound most plentifully; we pay millions of dollars annually for imported fertilizers; we have agricultural and industrial demands for ten times the

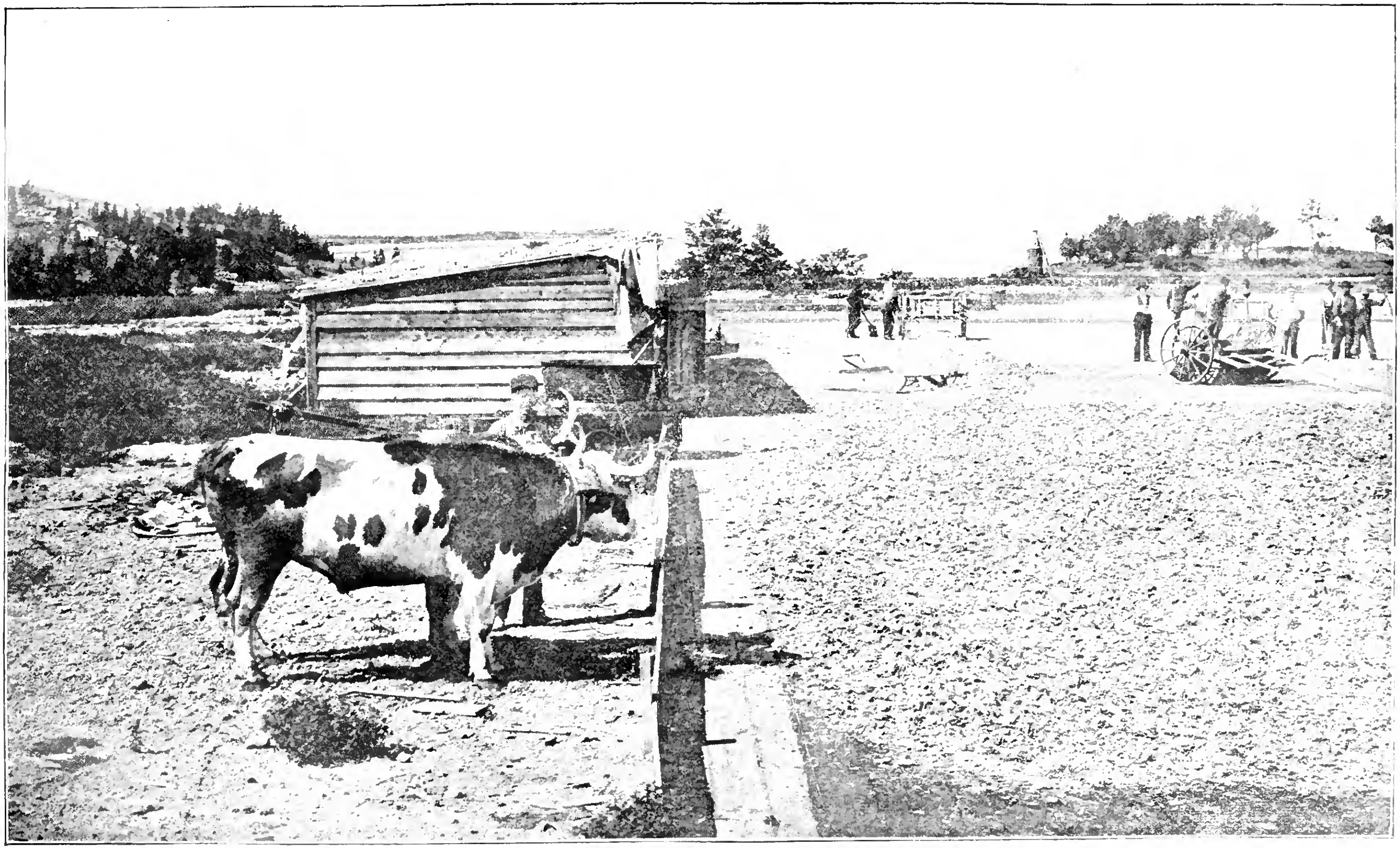


Fig. 5.—Part of a Drying Floor.

amount we have been producing; and we are assured beyond question that an abundance of fish, quite equal to these demands, swim along our shores, and that the capture of a sufficient number of them would not appreciably affect their plentifulness. Surely the legislation that prevents the development of this source of wealth must be at fault somewhere.

Such legislation exists in Maine, Massachusetts, New York, and Virginia; and the conditions under which these laws were passed deserve to be cited here. In considering these repressive enactments it will be apropos first to examine the arguments urged in favor of them. Three principal objections to the menhaden fisheries are made: First, that fishing for menhaden, mackerel, or any other fish with a purse seine (the appliance now used) depletes the supply of these fishes; second, that menhaden is the food of many of the food fishes, and the depletion or "driving away of the shoals" of this species by seining, forces the food fishes—mackerel, striped bass, bluefish, etc.—to seek other waters; and, third, that the enormous captures of menhaden for the purposes of making oil and guano prevent the procuring of bait for our cod and other fisheries; it being included in the third objection that inasmuch as cod, mackerel, bluefish, and other species are captured with menhaden bait, this latter fish is a natural food of the food fishes. It is also claimed that the shoals of fish are frightened by the purse seines, so much so that they cease to frequent the shores in the same abundance. These constitute in brief the objections to the capture of menhaden for oil and guano, and form the basis of the reasons why the States of Maine, Massachusetts, New York, and Virginia passed prohibitory laws.

Let us now examine the other side of the question. Before the Committee on Merchant Marine and Fisheries of the United States Senate, February 17, 1892, Mr. William F. Brown, of Philadelphia, said: "The annual value of our" (the Menhaden Association) "product for the last twenty years has averaged $1,500,000, more than two thirds of which is paid to the two thousand men employed. And when you consider that every dollar of this—more than $25,000,000—is a permanent clear addition to the wealth of the nation, because the crude material is taken from the sea; and when you have seen how generally the whole people are interested, directly and indirectly, in our success or failure, you will stand amazed at the recital of the persecutions and legislative wrongs to which we have been subjected." Further on Mr. Brown made a general denial of all the objections claimed by the opponents of the menhaden industry. This statement is backed up by the evidence of Mr. Eugene Blackford, of New York; of Captain Nathaniel Church and his brother Daniel T.

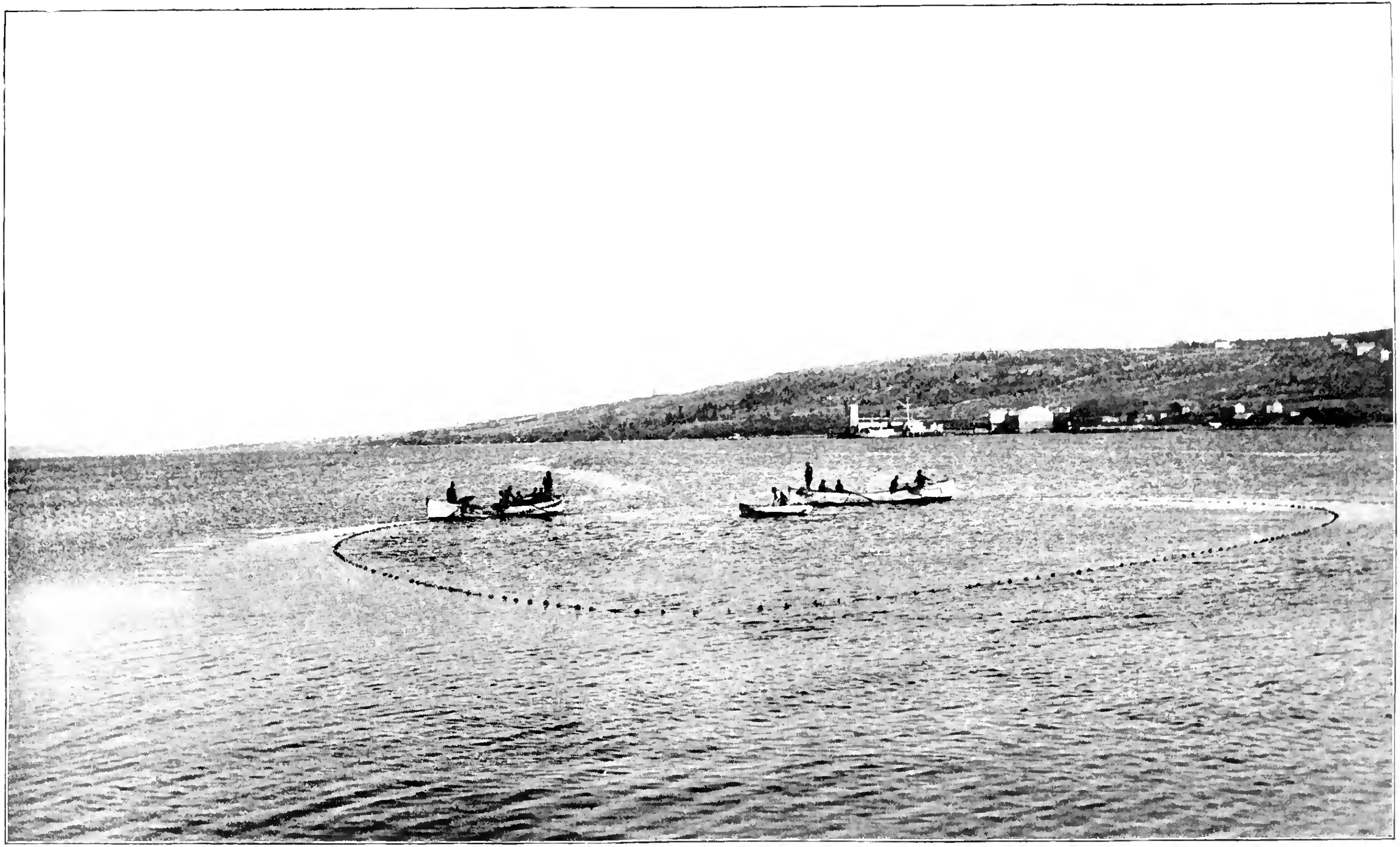


Fig. 6.—Shooting a Purse Seine.

Church, of Tiverton, R. I.; and by the opinions of Captain J. W. Collins, of the United States Fish Commission, Prof. G. Brown Goode, and many others scientifically and *practically* engaged in deep-sea and coast fisheries. For instance Captain Collins says:

"The researches and inquiries made by the Fish Commission, I think, show conclusively that certain species of migratory fishes, like, for instance, the mackerel and menhaden, are subject to influences which determine their abundance outside of anything that can be done by man—influences that are much more potent than man's are." In proof of this statement both Captain Church and Mr. Collins have drawn attention to the facts that, in the case of mackerel—and menhaden are, like mackerel, migratory and similarly influenced—seasons of scarcity may be and are followed by years of comparative plenty; and a series of seasons of scarcity may be followed by a gradual increase until an abundance is reached that is very surprising.

This disposes of the claim that purse-seine fishing affects the natural scarcity or abundance of fish on the coast. Mr. Church and Mr. R. E. Earle authoritatively deny the statements that food fishes are taken in the nets of the menhaden steamers. And Mr. Earle says that, when engaged, as an expert of the United States Fish Commission, to inquire into the menhaden fisheries, he did not see enough food fish taken for the table of the steamer as the result of several hauls of menhaden.

Right here it will be interesting to describe the method of seining menhaden, showing how it is almost impossible to capture food fishes other than migratory fishes in the purse seines. The steamers used in the menhaden fishery average about seventy-five tons register and have a carrying capacity of nearly one hundred and fifty tons. Each steamer is manned by twenty to twenty-five men, of whom sixteen are fishermen. When a school of fish is sighted, two boats put out from the steamer, each boat containing eight men. From one of these boats the net is "shot"—the other holding the top and foot lines of one end. The usual length of a purse net or seine is about eighteen hundred feet and the depth sixty to one hundred and twenty feet. As one of the boats rows around the school of fish, the net is thrown out from the other, and when the circle is made, both ends of the "bottom line" are drawn. This makes the "*purse*"; but it also allows the "bottom fish," which are practically all food fishes, time to escape; so that as a rule no fishes except the menhaden, or whatever kind of fishes are inclosed on the surface, are captured by the purse seines. The top lines are then drawn, and the bag or purse completed. The contents are then towed along to the steamer, where they are hoisted by steam, and the seine emptied into the "hold."

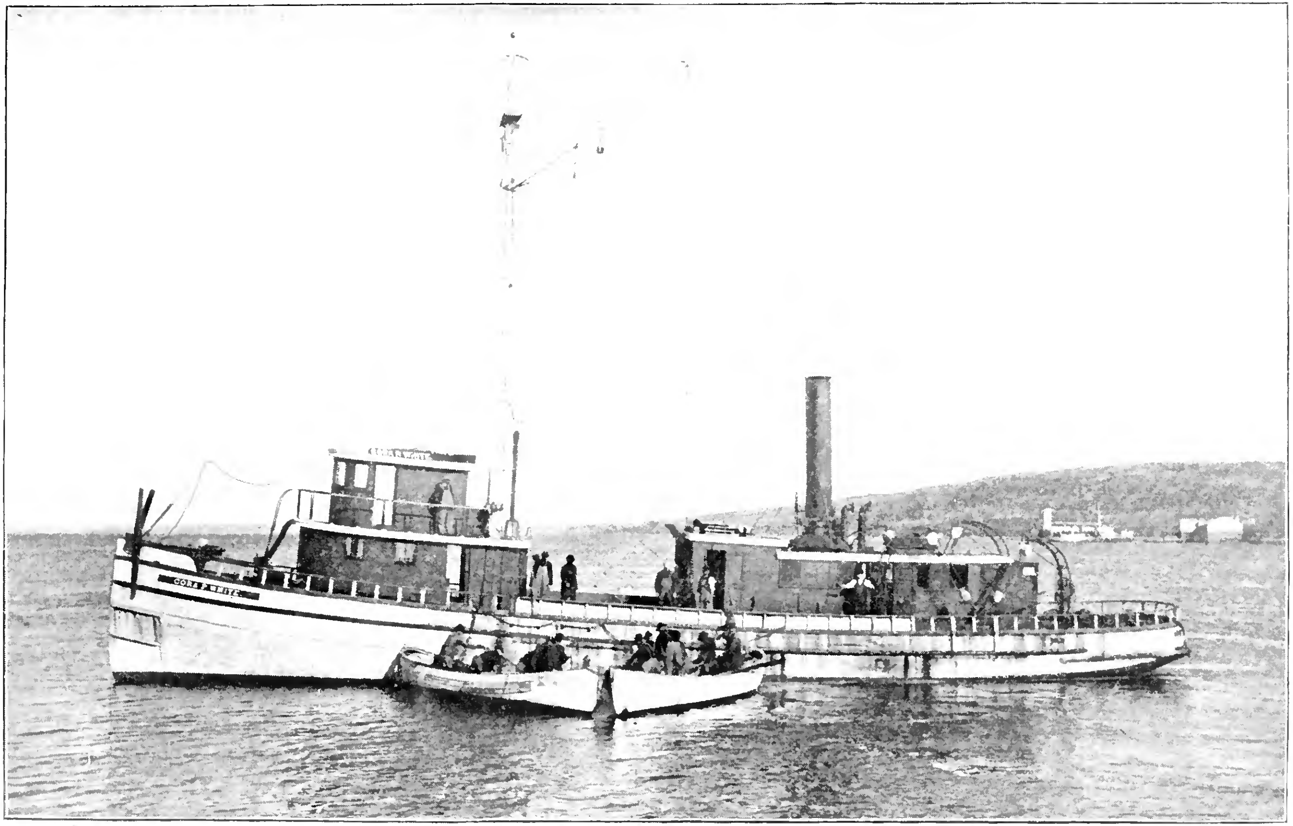


Fig. 7.—A Menhaden Steamer, showing Purse Seine about to be Emptied after a Haul.

It should be stated here that the meshes of every purse seine employed in the menhaden industry are two and seven eighths inches square, so that it is practically impossible to capture any immature fishes in these nets.

Aside from the operations of the factories, menhaden are used as bait for food fishes; a small quantity is salted and exported to the West Indies, where it is eaten by the negroes; and many more are plowed into the soil by farmers along the Atlantic coast, as has been the custom for centuries.

The question of the menhaden being used as food by the food fishes is practically disposed of by Dr. Bean, the ichthyologist of the United States Fish Commission, who testified that, having examined the stomachs of numbers of bluefish and other food fishes, he failed to find any evidence of the menhaden except in the form in which it is used as a bait for "chumming," and only in a very few cases was it present at all. Mr. Atwood, of Bristol County, Massachusetts, whose experience as a practical fisherman extends back to 1816, makes the following interesting statement:

"The great changes in our fisheries have been caused by the bluefish. . . . When they first appeared in our bay I was living at Long Point (Provincetown), in a little village containing some two hundred and seventy population, engaged in the net fishery. The bluefish affected our fishing (mackerel, menhaden, etc.) so much that the people were obliged to leave the place. Family after family moved away, leaving that locality, which is now a desolate, barren, and sandy waste." Passing over the depredations of the bluefish, Mr. Atwood says, "I firmly believe there is no necessity for the passage of any general legislative act for the protection or regulation of our sea fish and fisheries."

J. M. Rimbaud, a famous French ichthyologist and practical fisherman, says that the *migratory* fishes can not be diminished by overfishing; but that local fishes might be exterminated by constantly fishing for them. The Royal Commission appointed by Her Britannic Majesty's Government to inquire into the condition of the fisheries of Great Britain and Ireland, which consisted of Prof. Thomas Henry Huxley, Right Hon. James Caird, and the Right Hon. George Shaw Lefevre, after three years of exhaustive inquiry reported: "We advise that all acts of Parliament which profess to regulate or restrict the modes of fishing pursued in the open sea be repealed, and that unrestricted freedom of fishing be pursued hereafter." I heard Prof. Huxley state positively, in 1883, that after many years of study of the question he had come to the conclusion that the supply of migratory fishes, especially the herring, was inexhaustible.

I think I have now told enough about the non-edible fish in-

dustry of the Atlantic coast to show that it is an important source of national wealth, and I believe it will reasonably be deduced, from what I have written, that nothing but restrictive laws in several States prevents it from becoming of vastly greater importance.

PECULIAR SOUND EFFECTS.

By A. A. KNUDSON.

IN this article we propose to consider some of the peculiar features and effects of sound as we meet them in our everyday life, giving special reference to that very oft perplexing phenomenon the *location* of various sounds. In order that these remarks shall not extend beyond reasonable limits in our treatment of this broad subject, we shall confine them to sound effects as they originate *indoors*, and not so much to the origin and transmission of sounds in the atmosphere. The inability to determine at once whence a sound comes, or, as is often the case, locating it in the wrong place, occasions frequent trouble and annoyance, as we shall show by incidents in our own experience, extending over a number of years.

In order that those not familiar with the subject may obtain a fair idea of the peculiar effects of sound, as we shall herein illustrate, let us look briefly at some of its principles. In the science of acoustics, *sound* is simply vibrations or pulsations originating from an unlimited variety of causes, varying in amplitude, pitch, etc., passing through the intervening air, and acting upon the organs of the ear. The phonograph gives us an excellent illustration of the composition of these vibrations, for by examining with a magnifying glass the cylinder upon which the human voice has been placed either in spoken words or vocal music, we find all the vibrations which go to make up the different characteristics of sound faithfully recorded in the indentations upon the cylinder. I say *faithfully* recorded, because their correct reproduction is a proof of this—the result being the same also if other than vocal sounds are recorded upon the cylinder, such as music from instruments either single or combined.

If we follow the lines made by the vibrations closely, we shall see in the indentations deep and coarse punctures which represent the loud base notes of the male singer or speaker, while the fine, light, and more frequent indent represent the high notes of either a male or a female voice, and the same effect is produced by the vibrations of sounds made by musical instruments. The phonograph, therefore, enables us to capture, as it were, all manner of sounds, and to give them optical expression, while

their reproduction is the wonderful feature of the whole performance.

I was once present by invitation of Mr. Edison to witness a phonograph test in his laboratory at Orange, N. J., and by way of illustrating the power of reproduction of that instrument will state the result as witnessed by me. Some fifteen or twenty phonographs were placed in a semicircle in the room, all their cylinders running, and a band of music, including a piano, stationed near the center. After the band had played a selection from some popular opera, we examined their power of reproduction by putting on the ear tubes, and, beginning at one end of the row in company with Mr. Edison, tried each phonograph.

It was found that while some reproduced the music not as loud or as clearly as desired, owing probably to imperfect adjustment, the most of them were remarkable for their loudness of sound, and so clear and perfect that the sound of each instrument such as the piano, cornet, etc., could be distinguished *separately*. These cylinders were taken off and, after being labeled, filed away for future use. In the phonograph Mr. Edison has given the world a most useful and valuable invention; for, beyond the fact of its commercial value, it is a most important educator in the science of acoustics, as we have attempted to point out.

Many illustrations may be found in *electrical inventions* where the vibrating construction of sound is taken advantage of—for instance, the musical telephones of Prof. Gray and Edison, and such ingenious inventions as the harmonic telegraph of Gray, and the railway induction telegraph of Phelps and Edison. All these and many others employ the vibrating effect of sound to accomplish the desired results.

If we look for more common illustrations we may easily find them about us, such as the circuit breaker in the medical battery. By manipulating the adjusting screw, changing the number of vibrations per second, a variety of notes can be produced, from a a low rattle to a high, fine tone. The ordinary "buzzer" now common in business houses, which is largely taking the place of the electric bell, gives forth a note more or less musical according to the number of vibrations per second to which it is adjusted. The wings of the humming bird as well as those of insects furnish further examples of musical notes (not always welcome) by the rapid action of their wings against the air.

It will be observed, as this question is studied, that sound vibrations to be musical must be *regular*, otherwise they become simply noise. Prof. Tyndall, in his admirable work on sound, referring to this part of the subject, says that "a musical sound flows smoothly and without irregularity, and this is secured by rendering the impulses received by the tympanic membrane per-

fectly periodic; a periodic motion being one that repeats itself." And, again, quoting from Tyndall: "To produce a musical tone we must have a body which vibrates with the unerring regularity of a pendulum, but which can impart much sharper and quicker shocks to the air. The pulses, on the contrary, which produce *noise* are of irregular strength and recurrence." These illustrations will no doubt afford a fairly clear understanding of the creation and composition of sound, and we will now consider some of its effects.

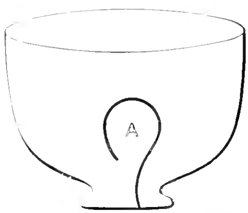
One peculiar phase in sound effects is the sympathetic response of objects in the vicinity of a sound or note, such as the responding vibrations of a violin string when a note on the piano is struck with which it is in harmony.

This peculiar effect, however, is by no means confined to musical instruments, for should there be any object in a room which by accident happens to be so placed as to be in unison or tune with some note of a piano, that object will respond by taking up the vibrations of the note sounded. This responding note being often accompanied by a disagreeable jarring sound (due to the article touching some object while vibrating), interferes with the harmony and is often the cause of much annoyance to ladies and others who may be playing the piano; besides, these foreign sounds are so deceitful as to their location that usually they seem to come from the piano itself, and it is generally very difficult to convince a lady that they are anywhere else, and in the ladies' opinion a piano tuner must be sent for as soon as possible. An instance or two which happened in my experience will illustrate this.

The first case happened in my own home a few years ago. My wife and myself were in the parlor, she playing the piano. Presently she stopped and impatiently said, "There, this piano is not right yet, and that tuner has been here three times, and this is the note he fussed over so long" (pounding on the same), "and it's just as bad as ever." The fact was, the last time the tuner called he went away very mad, stating that he never had had such a case in all his experience. Knowing all this, the remark of my wife set me to thinking, and I asked her to pound awhile on that bad key. Upon listening carefully about the piano the jangling noise did really seem to come directly from it; but determined not to be deceived, I started on a tour of investigation, first satisfying myself that there were no loose objects upon the piano itself. I began to look about the room among *bric-à-brac*, mantelpiece ornaments, etc., now and then receiving such encouraging remarks from the performer as "There is no use looking away over there for that noise, it's right here in the piano; don't you hear it?" But I said, "Never mind, keep on pounding."

With the sense of hearing exercised at its best, I continued the search, but had almost given it up when, upon crossing the room and passing under the chandelier, I thought I heard the jangle above my head. Getting upon a chair, I listened carefully at each one of the glass globes, and finally came to one where I could hear the jangle quite distinctly. Upon looking at this globe carefully I discovered a very peculiar crack in it. This crack in shape was almost a complete circle, but a small stem or portion of glass at its lower edge held the piece in place, so that it was in condition to respond to the vibrations of that note of the piano with which it was in tune, and in this case it was *the one* that was being sounded.

The accompanying sketch will give a very fair idea of the position and shape of this piece of glass at (A). Pressing a finger against it in order to stop its vibrating, and to be quite sure that



I had found the trouble, I asked the player if she heard the sound then. After several vigorous thumps she was obliged to confess that she did not. Taking away my finger and allowing it to vibrate as before, I asked again, "Do you hear it now?" The answer this time was, "Yes, it is there yet." Removing the globe, I announced the fact that the piano *was fixed*, much to the astonishment of the player, who found the statement correct. This incident illustrates how even the practiced ear of a musician can sometimes be deceived as to the location of sounds in music—to say nothing of the ladies, who would be excusable under such circumstances, as their sense of hearing is not expected to be so perfect as to detect such peculiar phases of sound.

Another interesting feature of peculiar sound effects is illustrated by this incident. While this loose piece of glass would respond and vibrate to *one* note of the piano, no other note would affect it, not even the sharp or flat of the one that caused it to respond.

If these responding objects, however, were free to vibrate without touching anything, such as a violin string, there would be no jangle, for as in the above case the edges of the broken piece of glass touched that of the globe, which caused the discordant sound, which I have termed for want of a better name the *responsive jangle*.

Another case similar to the above occurred in a house where I was once stopping in Nova Scotia. A piano with a bad note was fixed by simply opening an inside shutter of a bay window at the opposite side of a parlor from the piano. The latch of one shutter was lightly resting against the edge of another and

caused the jangle when one particular note was struck. The lady player had previously declared that she would send for a tuner the next day, and laughed at my attempt to fix it by hunting about the room while she pounded. However, she did not conceal her surprise when the trouble was removed, and admitted that there was something about this sound business that she did not quite understand.

In regard to locating these jangles, however, I will say that it is not always so easy. It requires some practice before the ear becomes capable of locating with any degree of success the direction of sounds of this kind. This was my experience with the first piano jangle, that of the cracked globe, which was quite difficult; that of the window shutter was easier, as well as many others which I have located since. A correct musical ear is also an important adjunct in the case. I have often observed the responsive jangle in concert halls, churches, etc. One church in particular in Brooklyn that I often attended had a responsive note high up in one of the windows which I was able to locate from the pew where I sat. I formed a sort of secret attachment for this jingling note, and I looked as much for it to respond every Sunday when the organist touched the proper key as for the audience to respond to the readings of the service.

Business called me away from home and church, and after a lapse of four or five years after returning home one of the first things I looked for on again attending church was my jangle. But alas! it was gone. During my absence inside windows had been placed over all the windows in the church, and my jangling friend was silenced. No doubt the cause of this jangle was some detached piece of glass from a cracked window pane, but it was too high up to be seen.

This locating of jangles originating from musical notes having become somewhat of a hobby with me, being almost always on the lookout for them, many curious instances similar to those I have mentioned could be related, but I will give only one other, which was the first that ever came under my notice, and which took place several years ago.

This most peculiar case happened in a church on an Easter Sunday. During the singing of a hymn I at once became conscious of an occasional discordant sound quite near where I stood (the congregation were standing), and this jangle was so marked that the music for me at least had no further charms. After listening in various directions I finally located it as coming from the mouth of an elderly lady who was singing with a good deal of vim in the seat in front of me. The fact was, her false teeth were loose, some of them at least, and the effect, notwithstanding the surroundings was to me more ludicrous than inspiring. In

this case it will be observed that the original sound and the jangle both came from the same place, so that it was not so difficult to locate.

There was no mistake about it, as the old lady sang through each verse, and at every verse the jangle appeared. She, however, seemed totally unconscious of any discordant effect in her vocal effort, and I have no doubt did not notice it at all.

The difficulty of locating sounds correctly may be illustrated in one way by the advantage the ventriloquist takes of this peculiarity, for in the exercise of his art he can speak in such manner that his voice appears to come from an image beside him, or from some distant place. Analogous to optical delusion, the ventriloquist might be well termed an exponent of sound delusion; and, again, the attempt to deceive an audience as to the source of sound by a supposed performer on the stage going through the motions of playing upon a cornet or other musical instrument while the real performer is behind the scenes is often successfully practiced. I was once present at a practical test made before an audience which will further illustrate how difficult it is to determine whence a sound comes. A gentleman took his seat in a chair upon the platform and was blindfolded. Another party held a snapper sounder in one hand and would produce the snap now directly over his head, now to one side, behind his back, etc. At each sound of the snapper the blindfolded party was requested to point in the direction from which he thought the sound proceeded. In almost every attempt he pointed in the wrong direction.

As a result of observations which I have made among animals, there is a wide difference between them as to the ability of distinguishing and correctly locating sound; for instance, men and women have not such an acute sense of quickly locating a sound as some of the four-footed animals, such as the rabbit, mule, the cat, and some species of dogs. It is quite probable that the ability these animals have to move their ears about, and long ears at that, accounts for the quickness they have for determining the direction of a sound. I have often tried the experiment of testing this sense of correctly locating sound with a cat by imitating the squeak of a mouse by whistling through the teeth. The first squeak or two would result in the cat springing up and, with ears erect and moving about, listen for the next sound; at the second attempt the cat would as a rule look directly into my face, as much as to say, "You can't fool me that way," would settle down again to its nap, and no further imitation squeaks would start it up again.

The not infrequent result of any unusual sound behind a mule illustrates how well his sense of hearing serves him in this re-

spect. It is pretty well known that the mule does not wait to turn his head to see if he has correctly located the sound, but will let his heels fly first and look around afterward. The *rabbit,* by reason of his long ears in proportion to his size, has probably the most correct sense of locating sound of all animals.

We mortals, however, not having long ears or the ability to move those that we have, often make sad mistakes in our attempts to correctly determine the source of various sounds. In other words, the hearing facilities coupled with instinct in animals are far superior to the hearing facilities coupled even with reason in human beings.

Among human beings, however, the Indian is probably the most correct in his interpretation and location of sound, whether in ascertaining the presence of a foe or in search of game his sense of hearing in this respect through long practice attains a much higher state of perfection than that of people in various commercial or professional occupations. From my observations I should say that such animals as I have mentioned would come first on the list as the most correct locators of sound, men next, and women last. I have already shown to some extent the difficulty ladies have in this respect, and by way of illustrating further will relate an incident which occurred in Brooklyn some years ago, which will show how easily they can be mistaken should they depend upon their first impressions. Soon after the introduction of that very useful invention the pneumatic door check, designed to prevent doors from slamming, one was fixed on the entrance door of the general post office on the inside near the top. When the door closes, as every one knows, the check emits a slight hissing sound, due to the air in the cylinder escaping through a small hole. (Some later designs are without this feature.) This hiss, which is very similar to the sound often made by boys and men through their teeth in attracting attention, but considered rather insulting if applied to ladies, was the cause of a good deal of trouble one day.

A lady called at the office, and no sooner had the door closed behind her, when *citt.* Immediately fastening her flashing eyes upon a clerk at the stamp window, she exclaimed: "So, you are the one; I have found you at last!" and then bolted into the presence of the postmaster, where she lodged a serious complaint, viz., that she had been insulted by the aforesaid young man, and this was not his first offense, for every time she had come into the office lately "that man would go *citt* with his teeth." The astonished postmaster immediately sent for the accused, who heard the charge against him, but of course indignantly denied having made any such sound through his teeth, never saw the lady before, etc., etc. Finally, after the rumpus had quieted somewhat,

an idea occurred to the postmaster, who was of a practical turn of mind, and he asked the lady to step out to the door a moment. Opening the door at which she entered, he let it close again, when *citt*, that insulting sound again. The lady was asked if that was the noise she heard, and she said, "Why, yes, that's it." Then the obliging postmaster explained to her the new door check, pointing up at the top of the door, how it worked, etc., much to the surprise and mortification of the lady, who apologized and soon left, muttering about the "new-fangled things men are always getting up."

The point I wish to make in this illustration is that the lady was completely deceived as to the location or source of this sound, and unfortunately put it in the wrong place, viz., in an innocent man's mouth several feet in front of her, when as a matter of fact it came from directly over her head. Many familiar instances of the inability of locating the source of vocal or other sounds occur every day, but I think sufficient has been said to at least put those on their guard who may read this article, should they meet with any such experiences.

In conclusion, I would suggest that the first impression of the origin or source of a sound should not be taken as absolutely correct if it is a case of importance, such as a responsive jangle produced by a musical note or accusing wrongly some innocent person, as in the case of the lady and the whistling door check. Should your piano be afflicted on one of its notes by an apparent bad sound or jangle, before sending for a tuner investigate a little on your own account while some one sounds the key.

If the trouble is due to a jangle in some part of the room, a tuner, if sent for, no doubt would "fix it," but he would in all probability tune the supposed bad string a little high or a little low, and for the time avoid the jangle in that way, collect his fee and depart, when the trouble would afterward reappear again as bad as ever. I would say further that I am not aware of any existing rules that will direct one in the correct location of sound. We can only use our ears and common sense as occasion requires, and if sometime errors are made they should not be wondered at, when the deceptive nature of the phenomena of sound is considered.

THE behavior of the luminiferous ether near matter has been investigated by Prof. Oliver Lodge. The question bears upon that of whether the earth in its motion carries the ether of space with it. Prof. Lodge moved a lump of matter and ascertained whether the velocity of light in the space near it is affected by the movement. He found no such effect, and concluded that the ether slips through a solid like wind through a grove of trees; and that the connection between ether and matter is not mechanical.

RELIGIOUS BELIEF AS A BASIS OF MORAL OBLIGATION.

By Prof. E. P. EVANS.

FOLLOWING the primitive period of tribal ethics* comes a second stage of social and moral development, which Mr. Maine calls the supersession of the bond of blood by the bond of belief. Ethnocentric attraction gives way to what might be called theocentric attraction, and a broader and more spiritual sort of association is formed, having for its basis, not consanguinity, but conformity in religious conceptions. The god takes the place of the human progenitor of the tribe, or rather grows out of his deification in the evolution of ancestor worship, which is probably the oldest of cults.

Nevertheless, in this case, the fundamental principle of primitive society, which makes friendship coextensive with kinship, is not abrogated, but only enlarged in its application, causing those who worship the same deities or propitiate the same demons to enter into fraternal relations and call themselves brethren.

The canonical prohibition of marriage between persons connected merely by the artificial ties of a religious rite, such as sponsors and baptized infants, godfathers, godmothers, and godchildren, proves how intimately the idea of ritual relationship was associated with that of real relationship in the minds of those who established and perpetuated this institution. This fiction of sacramental kinship was at one time carried so far in the papal Church as to forbid the sponsor to be joined in wedlock even to the parent of a godclild. Cohabitation between a *patrinus* and a *matrina* was regarded as incest until the Council of Trent removed the ecclesiastical bar to such unions. The fact that they had assumed the position of spiritual parents to one infant prevented them from becoming the real and lawful parents of another infant. The importance attached to the name-day, which in most Catholic countries quite supplants the birthday as an anniversary, is also additional evidence of the vigor and vitality of primitive conceptions as embodied in ecclesiastical institutions.

Religion is, in fact, as Schelling observes, the strongest cement of primitive society, and the influence which contributes more than any other to the evolution and organization of the nation and state out of the tribe. Plutarch says: "Methinks a man should sooner find a city built in the air, without any ground to rest upon, than that any commonwealth altogether void of re-

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* See Popular Science Monthly, January, 1894.

ligion should be either first established or afterward preserved and maintained in that estate. For it is this that contains and holds together all human society and is its main prop and stay." Hegel expressed the same idea when he asserted that "the idea of God forms the general foundation of a people." Herbart calls attention to the pedagogical and disciplinary value of religion in the early stages of man's development, since it teaches him to subordinate present desires to future welfare, to look to the remote results of his conduct, and to sacrifice momentary pleasures here to permanent advantages hereafter.

But the ordinary experiences of life, especially in a cold climate, are quite as effective in inculcating thrift and enforcing the first elementary principle of domestic and political economy—that a man can not eat his pudding and keep it too. Stress of hunger emphasizes the necessity of laying up stores of provisions against time of need, and teaches foresight and forehand more directly and more forcibly than any hypothetical relation of man to the gods could do.

Originally the tie of religion must have been identical with the tie of relationship, and the brotherhood of belief coextensive with the brotherhood of blood, since all members of the same family or tribe would naturally adore the same domestic or tribal deities. Without this acceptance of the tribal theology and traditions by every individual of the tribe, the public peace would be constantly disturbed and the very existence of primitive society imperiled.

With the lapse of time and the increase of intelligence, however, vague wonder and ignorant worship would give place in more thoughtful minds to obstinate questionings, blank misgivings, and stubborn skepticisms, leading logically and inevitably to open schisms, and resulting in the formation of new communities of faith, crystallizing around the nucleus of a vital religious conviction. It was then proved, what all later history confirms, that spiritual affinities have a stronger cohesive attraction than natural affinities, and that, in every case of tension, the latter are sure to yield and be rent asunder.

Even the founder of Christianity, who professed to proclaim a gospel of peace on earth and good will to man, foresaw and did not hesitate to declare that this sundering of the closest consanguineous connections and division of families into hostile factions would be the necessary consequence of his teachings. He spoke of his doctrines as a sword destined to sever the nearest ties of natural affection and affinity, setting the son at variance against the father, and the daughter against the mother, and converting the members of a man's household into his bitterest foes.

The center of cohesive attraction, which binds the new com-

munity so firmly together and so relentlessly ruptures all older associations, is the creed, or what is known in Christian theology as the symbol, the same term that, as we have already seen, was used by the Greeks to denote the token or pledge of hereditary hospitality and friendship between families, which furnished a basis for the formation of treaties of amity and commerce between tribes.

Strictly tribal religions never proselytize. Instead of seeking to share with alien tribes the favor and protection of their gods, they wish to monopolize whatever power and patronage may be derived from this source as a means of rendering themselves superior to their enemies. This was the case with the ancient Hebrews, who never thought of sending missionaries into other lands to make converts to Jehovah, but would have condemned such a procedure as treasonable. It is true that Jesus, in his denunciation of the Pharisees, declared that they "compass sea and land to make one proselyte"; but this reproof referred to their zeal as a political party in winning adherents among their own countrymen, in order to supplant the more liberal-minded and less rigidly ritualistic Sadducees in the Sanhedrin.

Jesus himself evidently never intended to break away from Judaism and to become the founder of a new religion. According to his own statement, he was "not sent but unto the lost sheep of the house of Israel." His mission was not to destroy, but to fulfill; not to abrogate, but to accomplish the law. He sought to give a spiritual interpretation to ancient precepts and injunctions; to revivify and rehabilitate the moral sentiment, hitherto dwarfed and deformed under the heavy burden of a perfunctory ceremonialism; and to enforce the commandments of God free from all incrustations of the traditions of men.

Curiously, and yet naturally enough, it was out of the very strictest sect of the Pharisees, so severely rebuked on account of their proselytic spirit, that the great proselyte Paul came—the man whose breadth of view and energy of purpose changed a local reformatory movement, which seemed to have been practically suppressed by the crucifixion, into a world-wide religion, by emancipating it from the fetters of Mosaic formalism, taking it out of the narrow *ghetto* of tribalism, and imparting to it a universal character. In this bold effort to turn apparent disaster into permanent victory, by breaking through the barriers of Judaism and preaching the gospel to the Gentiles, he met with the most determined opposition from the near kin and personal friends of Jesus, as well as from the principal disciples in Jerusalem.

To this process of development—by which Christianity, whose "field is the world," rose out of Judaism, the special cult of a

privileged race—we have a parallel in the historical evolution of Buddhism, as a religion of pure humanity aspiring to universality, out of the narrow exclusiveness of Brahmanism with its rigorous politico-ethnological system of hereditary caste.

If, however, we go back to an earlier period, we meet with a most striking example of the workings of these conflicting forces in the disintegration and reconstruction of old Aryan society, thirty centuries ago, in the highlands of Bactria. The nature of this epoch-making movement, which took place as the result of Zarathustra's teachings and under his leadership, and the deep and enduring enmity it excited between people of the same blood, are perceptible in the solemn pledge or confession of faith by which the proselyte was received into the fellowship of the Iranian community.

This remarkable document, written in the ancient Gatha dialect, which is surmised to have been the vernacular of Zarathustra's native province and the mother-tongue of the prophet, begins with an abjuration of the ancestral deva worship and a vow of devotion to the glorious and munificent Ahuramazda, and then proceeds to a renunciation of all evil works, and especially of those deeds of violence peculiar to nomadic freebooters: "I choose the beneficent Armaiti (earth), the good. May she be mine! I detest all fraud and injury done to the spirit of the earth, and all damage and destruction to the homes of the Mazdayasnians. I permit the good spirits, which dwell on the earth in the form of good animals (such as sheep and kine), to roam undisturbed according to their pleasure. I praise, besides, all offerings and prayers to promote the growth of life. I will never do harm or hurt to the habitations of the Mazdayasnians, neither with my body nor with my soul. I forsake the devas, the wicked and malicious workers of iniquity, the most baneful, most malignant, and basest of beings. I forsake the devas and their like, the wizards and their allies, and all creatures whatsoever of such kind. I forsake them in thought, in word, and in deed. I forsake them hereby publicly, and declare that all their deceits and lies shall be put away." After further asseverations in the same strain, and after renouncing anew the devas, and entering into covenant with the waters, the woods, and the living spirit of Nature, and accepting the creed of the fire-priests, the diffusers of light and of truth, the convert concludes by avowing himself to be a disciple of Zarathustra, an adherent of the pure Ahuryan religion, and a member of the righteous brotherhood. Henceforth he is a sworn foe of the evil-doing, ancestral deities, and a zealous co-worker with Ahuramazda in promoting good thoughts, good words, and good deeds—*humata, hûkhta, hvarshta.*

With this proclamation of a purer religion the promulgation

of a higher law of social life and a superior form of civilization was genetically connected—namely, the sacred duty of fostering and gladdening the spirit of the earth (personified as the goddess or angel Armaiti), by tilling the soil and making it fruitful. Husbandry is holiness to the Lord. In the third *fargard* of the Vendidâd this conception of agriculture as a sacred calling is particularly enlarged upon and enforced. The earth is there compared to a beautiful woman, who fails to fulfill her noblest functions so long as she remains virgin and barren. "He who cultivates barley cultivates righteousness, and extends the Mazdayasnian religion as much as though he resisted a thousand demons, made a thousand offerings, or recited a thousand prayers." Indeed, the best way to fight evil spirits is to redeem the waste places which they are supposed to inhabit. The spade and the plow are more effective than magic spells and incantations as means of exorcism. An old Avestan verse, which is quoted in inculcation and encouragement of tillage, and may have been sung by Iranian husbandmen as they sowed the seed and reaped the harvest, celebrates the influence and efficacy of their toil in discomfiting and driving out devils:

> "The demons hiss when the barley's green,
> The demons moan at the thrashing's sound;
> The demons roar as the grist is ground,
> The demons flee when the flour is seen."

[These lines have also in the original a sort of rude rhyme or assonance peculiar to ancient poetry:

> "Yadh yavô dayât âat daêva gîs'en,
> Yadh s'udhus dayât âat daêva tus'en;
> Yadh pistro dayât âat daêva uruthen,
> Yadh gundô dayât âat daêva perethen."
>
> Vendidâd, iii, 105–108, Spiegel's ed.]

If the Mazdayasnian religion, as revealed in the Avesta, illustrated in a remarkable manner the Benedictine maxim *laborare est orare*, it had no sympathy with the melancholy salutation *memento mori*, with which the Trappist greets the members of his silent brotherhood. As taught by the Iranian prophet and still practiced by the modern Parsis, it is pre-eminently a religion of thrift, and enjoins as a sacred duty the honest accumulation and hearty enjoyment of wealth. Poverty and asceticism have no place in its list of virtues. Voluntary abstinence from the pleasurable things of the good creation is an act of base ingratitude and treason toward the bountiful giver of them. He who despises them is a contemner of Ahuramazda and an ally of the devas, and contributes thus far to the triumph of evil in the world. The righteous man should not dwell upon the idea of

death, but banish it from his thoughts and earnestly strive after the realization of a fuller and richer life. It is the height of folly to suppose that mortifications of the flesh can further spiritual growth. Whatever fosters the health of the body favors the health of the soul; but the emaciation of the body impoverishes the soul. The notion which underlies what is known as "muscular Christianity" pervades the entire Avesta and finds a naïve and pithy expression in the following text of the Vendidâd, which the tiller of the soil is directed always to bear in mind and frequently to repeat:

> "Who eateth not for naught hath strength,
> No strength for robust purity,
> No strength for robust husbandry,
> No strength for getting robust sons."

[Here, too, we have a bit of old poetry passed into a proverb. In the original the only trace of rhyme (and this we have preserved in the rendering) is the assonance of the second and third lines:

> "Naêchis aquarentam tva,
> Nôit ughrâm ashyãm,
> Nôit ughrâm vas'tryãm,
> Nôit ughrâm putrôistêm."
>
> Vendidâd, iii, 112–115.

The editorial bracketing of the last line by Prof. Spiegel, as a possible interpolation, indicates an excess of critical suspicion, since this line not only fills out the verse, but also finishes up the thought, rounding and completing the expression of the sentiment with a climax.]

In another passage Ahuramazda declares: "Verily I say unto thee, O Spitama Zarathustra! the man who has a wife is far above him who begets no sons; he who has a household is far above him who has none; he who has children is far above the childless man; he who has riches is far above him who is destitute of them. And of two men, the one who fills himself with meat is filled with the good spirit (*vôhu manô*) much more than he who goes hungry; the latter is all but dead; the former is above him by the worth of a kid (*as'perena*), by the worth of a sheep, by the worth of an ox, by the worth of a man. [*As'perena*, usually rendered weight or coin, is derived from *a* + *s'par*, and means not walking or not grown, a young animal, a kid or a lamb. Cf. Sanskrit *sphar* or *sphur*, to expand or to swell.] Such a person can resist the onsets of As'tôvîdhôtus (the demon of death); can resist the self-moving arrow; can resist the winter fiend, even though thinly clad; can resist and smite the wicked tyrant; can resist the assaults of the ungodly Ashemaogho (the destroyer of purity) who does not eat." (Vend. iv, 130–141.)

According to Herodotus (i, 136), the Persian king gave prizes to those of his subjects who had the greatest number of children. Vigorous procreation was one of the most effectual means of grace. It is stated in the Sad-dar that "to him who has no child, the Chinvad bridge (leading to paradise) shall be barred. The first question the angels who guard this narrow passage will ask him is whether he has left in this world a likeness of himself; if he answers in the negative, they will leave him standing at the head of the bridge, full of sorrow and despair." In the same work that contains this piece of eschatology it is also written: "There are those who strive to pass a day without eating and who abstain from meat; we, too, have our strivings and abstainings, namely, from evil thoughts, and evil words, and evil deeds. Other religions prescribe fasting from bread; ours enjoins fasting from sin."

The Brahmans maintained that the man who died without a son went to perdition, because there was no one to pay him the traditional family worship; hence the necessity of adopting a son in case he had none of his own. The Levitical law, as we have already seen, compelled a man to take the wife of a deceased brother, who died childless, and raise up seed to him. In the Persian Rivâyats, or collections of traditions, similar matrimonial prescriptions are given. Thus, if a man over fifteen years of age dies childless and unmarried, his relations are to provide a maiden with a dowry and marry her to another man. Half of the children resulting from this union are to belong to the dead man and half of them to his proxy, the actual husband, and she herself is to be the dead man's wife in the next world. This kind of wife is called *satar*, "adopted." Again, if a widow, who has no children by her first husband, marries again, half of her children by the second husband are regarded as belonging to the first husband, and she also belongs to him in the future life; such a wife is called *chakar*, "serving." The first child of an only daughter belongs to her parents, if they have no sons, and they give her one third of their property in compensation. This kind of wife is called *yukan*, or "only child" wife. (Dr. E. W. West, Pahlavi Texts, in The Sacred Books of the East, vol. v, p. 143.) All these laws and customs show the vital importance attached to the possession of male offspring and to the preservation of an unbroken succession in the line of descent.

There are strong indications that the transition from pastoral to agricultural life in old Aryan society preceded the transformation of religious conceptions, and that the latter grew up gradually as a means of concentrating and more completely consolidating the former. In the second *fargard* of the Vendidâd a curious account is given of Yima, who lived before Zarathustra and is

spoken of as a king rich in herds and a man of renown in Airyana-Vaêjô, the Eden of the race. It was this exalted personage whom Ahuramazda is said to have first chosen to be the promulgator of the true faith. But Yima, the son of Vîvanghañt (a name derived perhaps from *vangh*, to dwell or abide, and meaning settler or dweller in fixed habitations), excused himself, on the plea of unfitness for the prophetic office. He may have been, like Moses, a man of deeds rather than of words, "slow of speech and of a slow tongue." Then said Ahuramazda, "If thou wilt not be the bearer and herald of the faith, then shalt thou inclose my habitations and become the protector and preserver of my settlements." Thereupon he gave him a golden plowshare and a goad decorated with gold as insignia of his royal office. [The word *s'ufra* I prefer to translate "plowshare" rather than "sword" with Haug, or "lance" with Spiegel. It means literally a *cutting* instrument. In the Avesta, plowing is called "cutting the cow"; and in the Vedic hymns the phrase "cut the cow" is equivalent to "make fertile the earth." "The soul of the cow" (*gêush urvâ*) means the spirit of the earth or the animating energy of Nature. In the Pahlavi translation of this passage *s'ufra* is rendered by *sûlâk-homand*, "having holes" or "sieve," and might therefore correspond to the Sanskrit *s'ûrpa*, "winnowing tray." The Pahlavi for plowshare is *sûlak*, and the close resemblance of this word to *sûlâk*, "hole," modern Persian *sûlâkh* and *sûrâkh*, may have led to a confusion and interchange of terms, both of which involve the idea of piercing or perforating.]

And Yima bore sway three hundred years; and the land "was filled with cattle, oxen, men, dogs, birds, and red blazing fires," until there was no more room for them therein. Then Yima went southward (literally, "toward the stars on the noonday path of the sun"), and, invoking the bounteous Armaiti, touched the earth with the golden plowshare and pierced it with the goad; and, in obedience to his behest, the earth expanded and became one third larger than before. This process he repeated, according to the Zand, after six hundred years and again after nine hundred years, with a constantly increasing extension of the earth, which finally became about thrice its original size, and thus afforded ample space for men and kine.

It is not difficult to discover the meaning of this legend. It is the mythical statement of the effect of agriculture in practically enlarging the surface of the earth by increasing its capacity for supporting animal life, and thus rendering it possible for a greater number of persons to subsist on the products of the same area of soil. A tract of country which would furnish precarious food for a single hunter, or pasturage for a score of herdsmen, would, even under rude tillage, easily supply sustenance for a

hundred husbandmen. Indeed, it has been estimated that one acre of arable land will bring forth as much food and consequently sustain as many inhabitants as two thousand acres of hunting ground.

In the fullness of time Yima was succeeded by the man who, like Aaron, could "speak well," and in the first Gâtha we find an address which Zarathustra delivered to his countrymen congregated around the sacred fire. It begins as follows: "I will now reveal to you who are here assembled the wise words of Mazda, the worship of Ahura, the hymns in praise of the good spirit, the sublime truth, which I see rising out of the sacred flames." He then appeals to them as the "offspring of renowned ancestors" to rouse their minds and give heed to his divine message: "To-day, O men and women, you should choose your creed."

After this brief exordium, he plunges at once into his subject and offers his solution of the old and ever-puzzling problem of good and evil, which he personifies as twin spirits, counter-workers in the creation of the world, each exercising its peculiar activity and contributing its characteristic element, and promoting respectively the happiness and the misery of mankind. It may also be safely asserted that, from a theistic point of view, no more logical and satisfactory solution of the difficulty has ever been presented. He earnestly exhorts his hearers to follow after the good and to eschew the evil. "Choose between these two spirits, for ye can not serve both." "Be pure and not vile." "Let us be such as help the life of the future." "Obey, therefore, the commandments which Mazda has proclaimed and enjoined upon mankind; for they are a snare and perdition to liars, but prosperity to the believer in the truth and the source of all bliss."

The whole aim of this discourse, of which these extracts suffice to indicate the drift, is to persuade his hearers to renounce or to confirm them in their renunciation of the old Aryan polytheism and worship of the devas, as we find it in the Vedas, and to adopt monotheism or the adoration of the one great and good but by no means omnipotent being, Ahuramazda. As a philosophical system, his doctrine was dualistic and recognized the existence of two original and independent principles in the universe; as a cult, it was monotheolatrous and worshiped only one of these powers.

It may be added that long before the close of the Vedic period the Indo-Aryans had also begun to devote themselves to husbandry, although their chief wealth still consisted in herds. The burden of their hymns and prayers to the gods is for much cattle and a large family of vigorous sons. The foes which they now had mostly to contend with were the Dasyus or aborigines of

India. The occasional mention of Aryan enemies may be partly reminiscences or records of an earlier time and partly references to intertribal warfares, of which there was evidently no lack. It must be borne in mind that all the Vedic hymns appear to have been composed in northern India, and principally in the region now known as the Panjâb. In none of these poetical productions do we find any distinct remembrance of a trans-Himalayan origin or any definite allusion to a former residence outside of India. This circumstance proves that at the time of the supposed migration from the North the ancestors of the Indo-Aryans must have been rude barbarians, destitute not only of written records, but also of the ability to preserve and transmit from generation to generation traditions of great events in their own tribal or national history. The savage has a short memory for whatever lies beyond the sphere of his individual experience.

One of Zarathustra's chief injunctions was to "listen to the soul of the earth," and to "succor and foster the life of Nature." This is to be done by cultivating and fertilizing the soil; since the increase of its productivity augments the sum of vitality in the world and contributes to the ascendency of the *vohumanô* or good mind, synonymous with *vis vitalis* or living force, and aids in securing the supremacy of Ahuramazda. Instead of bowing down in servile fear before the phenomena of Nature, the Mazdayasnians are directed to revere and cherish her kindly and beneficent spirit, so that "the wilderness and the solitary place shall be glad for them, and the desert shall rejoice and blossom as the rose."

Angrô-Mainyush and his satellites, the devas, on the other hand, are constantly striving to resist and to thwart this purpose and to keep the earth in her native state of virginal wildness and ruggedness by investing her with the dread sanctities and superstitions of a crude polytheistic physiolatry, by assaulting and ravaging the cultivated settlements of the Ahuryan agriculturists, and by fomenting and fostering the spirit of primeval savagery, personified as *Akemmanô*, or the evil mind. In the sacred books and traditions of both factions, and more especially in those of the reformatory party, are frequent traces of this social rupture and religious schism, and of the deadly hostility naturally existing between nomadic hordes, that still adhere to a life of pasturage and pillage, and men of more advanced ideas, who dwell in fixed habitations (*gaêthas*) and devote themselves to husbandry.

I am well aware that M. James Darmesteter and other representatives of what might be called the meteorological school of Avestan scholars deny the historical reality of a religious schism of the kind here described, and would reduce Zarathustra and all

the incidents of his life to a series of solar myths. It is, however, only on the theory of a religious schism that the fact that the deities of Brahmanism are the devils of Zoroastrianism, and *vice versa*, can be adequately explained. To assert that this antagonism is the result of an "accidental selection" of gods is no explanation at all. The religious history of mankind is not a record of casualties or mere chapter of accidents.

Besides, we have a modern example of a similar enmity growing out of the transition from nomadic to sedentary life in the mythology of the Dards, who are, perhaps, one of the oldest races and most primitive peoples of the East, and who believe in the existence of demons called *yatsh* (bad), which, like the Homeric Cyclops (the barbarous aborigines of the Sicilian coast), are of gigantic stature, and have only one eye, set in the middle of their forehead. These demons haunt the mountains and the wilderness, and are exceedingly hostile to agriculturists, whom they vex and harm in every possible manner, stealing and destroying the crops, and even carrying off the husbandmen to their gloomy caverns. In this scrap of mythology we have the survival of the old strife between barbarism and civilization, which began with man's first efforts to improve his condition.

The barbarian is, in fact, the most uncompromising incarnation and typical representative of conservatism; and it is the survival of the barbarian temper of mind that constantly hampers progress and hinders reform in modern times. His daily life is the dullest routine and would be unbearable, were it not the outcome and expression of the general rigidity and sterility of his intellect. He treads religiously in the footsteps of his forefathers, generation after generation, the whole mass moving on bodily and mentally in single file, as is the custom with savages. He is the stubborn foe of all innovations, and punishes as treason against the tribe every deviation from the beaten trail. Under such circumstances no social transformation can be effected without fierce battle and bloodshed. In the primitive history of mankind, as in the early physical history of the globe, great changes are uniformly the result of great convulsions.

It is not merely the love of booty that leads nomadic tribes to attack and lay waste the permanent settlements of husbandmen, but the instinct of self-preservation resisting the encroachments of a new form of social organization which imperils the old. For this reason hunters are hostile to herdsmen, and herdsmen to tillers of the soil; since pasturage diminishes the extent and value of hunting grounds, and agriculture diminishes the area of pasturage.

Mr. D. Mackenzie Wallace gives a striking illustration of this antagonism in the history of the Cossacks of the Don, who, so

long as they lived by sheep-farming and marauding, prohibited agriculture under pain of death. This severe interdict of a peaceful pursuit originated, not as some have supposed in the desire to foster the warlike spirit of the people, but rather in a perception of the fact that "the man who plowed up a bit of land infringed thereby on his neighbor's right of pasturage." By this act he became in a certain sense guilty of treason against pastoral society, the very foundations of which, the green sod, he broke up and destroyed with his plowshare. He not only restricted and reduced the actual area of grazing, but also struck a blow at the life of a cattle-rearing community. The practical workings of this crude and clannish conception of patriotism are recorded, as Mr. Wallace observes, on the pages of Byzantine annalists and old Russian chroniclers, who describe the periodical havoc of farmsteads committed by the nomadic tribes which from time immemorial had roamed the vast plains north of the Black and Caspian Seas, razing the houses, ravaging the fields, and leaving the bodies of the husbandmen as food for vultures.

The roving Bedouins, dwellers in the desert, as their name implies, despise the cultivators of the soil and call them contemptuously *fellahin* (plowers, boors); and their kinsmen the Anasis (*anâsî*, men) hover on the borders and levy blackmail on the villages of Syria. It is also significant for the persistency of this primitive point of view that the Arabic word for agriculture (*falâhat*), should also mean "fraudulent traffic," as though the permanent possession of a piece of land and the exclusive use or sale of the products of the soil were in themselves swindling operations.

These facts of to-day suffice to show the kind of opposition which Zarathustra had to face in his efforts to establish the Iranians in fixed settlements and to accustom them to the acquisition and proper utilization of landed property. In order to accomplish this purpose it was necessary to teach the holiness of husbandry and to invest seedtime and harvest with the sanctity of religion.

The Mormons, after their migration to Salt Lake, where the very existence of the community depended upon converting the desert into a garden, inaugurated the same policy, declaring through the mouth of their prophet that the human race could be redeemed and paradise regained only by means of tillage and making agriculture a sacred vocation and the pursuit of it a prominent part of their creed.

The priests of the old deva cult, the progenitors of the Brahmans, on the other hand denounced Zarathustra as a schismatic and a renegade, a contemner of the gods and blasphemer, a scorner of ancient custom and subverter of social order. They therefore opposed the innovation and fought for the faith of their fathers

with such clumsy weapons as they were most skilled in wielding, looting the homesteads, uprooting and trampling down the green blades of wheat and barley, which stood as representatives of the growing heresy, and, with a logic peculiar to theological zealots and ecclesiastical inquisitors in all ages, refuting the new doctrine and resisting the reformatory movement by greater energy and assiduity in the ancient and honorable calling of cattle-lifting.

As we have already seen, the duty of a man to shield and sustain a tribesman against an alien under all circumstances is imperative. Acts of extortion, treachery, or violence, which would be punished by death if committed against a member of the same tribe, are regarded as indifferent or laudable when the injured person is a foreigner. The same tendency to approve or to extenuate the bad conduct of "brethren" enters also more or less into the ethics of communities or collective bodies which are held together by the bond of belief.

All people in a low state of civilization have a strong prejudice against lending money on interest, and look upon all such transactions as sinful. The same notion still prevails among the lower classes of civilized nations, whose superstitions are in most cases mere survivals of savage life. So strong is this feeling, inculcated and consecrated by religious teachings and traditions, that a certain stigma attaches to the money broker even in the minds of otherwise intelligent persons. "Many lend money on interest," says Cato, "but it is not honorable to do so. Our ancestors enacted in their laws that the thief should restore twofold, but the taker of interest fourfold, from which we see how much worse a usurer was thought to be than a thief."

In general, however, usury, like every other supposed crime, was regarded as wrong only when applied to kindred or tribesmen. The Jews were forbidden to "take a breed of barren metal" from those of their own faith, but might exact it from Gentiles. Curiously enough, in the middle ages this privilege was granted to the Jews, not in the spirit of favoritism, but as a necessity to sovereigns and to society and from feelings of utter scorn and contempt. As neither government nor trade could do without this vilely esteemed vocation, the Jews were selected to carry it on, because they were considered a vile people incapable alike of improvement or of deeper degradation. The state and the Church, which felt an interest in the spiritual welfare and safety of the Christian, were wholly indifferent to the future fate of the Jew. That sweet saint, Bernard of Clairvaux, surnamed the honey-flowing teacher (*doctor mellifluus*), urged the rulers of his day to tolerate the Jews, not because he hated persecution, but in order that Christians might not be constrained to imperil the salvation of their souls by the sin of usury. The Israelitic pariahs of me-

diæval society rendered the same service to Christian virtue that professional prostitutes do to female chastity. We have a striking illustration of this point of view in a decree issued in 1219, by the German emperor Frederick III, permitting the Jews to dwell in Nuremberg and to take a percentage for the use of money. Inasmuch as this business, he said in justification of his edict, is essential to the growth of commerce and the prosperity of the city, it will be a lesser evil and wrong for Jews to practice usury than for Christians, since the former are a stubborn and stiffnecked race, and, if they persist in their perversity, as they probably will do, are doomed to be damned anyhow.*

The Hebrew, on the other hand, heartily reciprocated the Christian's contumely, and could hardly conceal, under the prudent disguise of mock humility, his disdain for the upstart Nazarene. He not only deemed it a religious duty to cheat him in money matters, but thought it perfectly right to use him as an agent in base or criminal transactions which a good Israelite could not conscientiously perform.

This mental and moral attitude, which even the modern Hebrew still maintains, is strikingly exemplified by the following incident: Between 1820 and 1830 a band of burglars, numbering over one hundred persons and consisting entirely of Jews, made property so unsafe as to create a panic among the inhabitants of the Prussian provinces of Posen and Brandenburg. The chief of the band was a certain Loewenthal in Berlin, and all the members of it were extremely devout attendants of the synagogue and strict observers of every jot and tittle of the Levitical law. They never broke into the houses of Jews and never stole on the Sabbath, since such an act would be a desecration of the sacred "day of rest"; but, rather than let an exceptionally favorable opportunity escape, they sometimes employed a so-called *schabbesgoï* [*schabbesgoï* (Sabbath-Gentile) is a Jew-German term for the Christian attendant or servant who does for an Israelite on the Sabbath the things which his religion forbids him to do for himself] to commit the crime for them, and, if necessary, did not hesitate to have some one of their own number accompany him on his burglarious expedition a couple of thousand yards or so, the limits of a Sabbath day's journey. In case one of the band was suspected of any particular offense and arrested, the surest and speediest way of clearing himself was to prove an *alibi* by the testimony of two witnesses, as the law required. But the pious Hebrew regards perjury with peculiar abhorrence, and fears above all things to take a false oath. Shylock was

* [We have referred to this characteristic decree in The Popular Science Monthly for December, 1891, p. 176, in illustration of another subject.]

eager to cut the heart out of his hated enemy, but he would not lay perjury upon his soul—no, not for Venice! The burglars kept, therefore, in their pay two Christians, who were as ready to forswear themselves as any Tammany Hall politician at the polls, and who made the requisite false oaths at fixed rates.

These examples serve to show the natural tendency of mankind to look upon compatriots and coreligionists from a different moral standpoint from that with which they regard persons who are not connected with them by such ties, and to whom they not only attribute a lower standard of right and wrong, but also act upon it as a rule of conduct in dealing with them.

Great dissimilarity in physical characteristics intensifies the ethical estrangement caused by differences of blood and of belief. The more any tribes of men deviate from ourselves in form and feature, the less we are inclined to think of them as endowed with the same powers and passions, the same kind of sympathy and sensibility as ourselves, or as entitled to the same rights that we possess. A people with black skin, woolly hair, flat noses, and countenances of a strongly prognathous character do not enlist our kindly feelings and awaken our affections in the same manner and degree as representatives of a fair-complexioned and finely featured type would do. The schemes of European governments and of private individuals and corporations for the exploration, partition, and colonization of Africa are based upon the assumption that the Africans themselves have no claim to the continent which they inhabit. The only African colony that has ever been founded on principles of common justice and with a full recognition of the rights of the natives is the Republic of Liberia, established more than sixty years ago under the auspices of the United States, and this was done solely for the sake of getting rid of an undesirable population of free negroes at home. All the other enterprises of this sort are morally and legally no better than buccaneering expeditions.

The ethical maxims which we are wont to accept as axiomatic in our mutual relations as civilized individuals and nations are too easily set aside as inconvenient and inapplicable to our dealings with the so-called lower races. The fatal facility with which under such circumstances enlightened Europeans of the nineteenth century may revert to primitive savagery as soon as the outward restraints of civilization are removed is seen in the early settlers of Australia, who did not scruple to shoot the defenseless and harmless aborigines as they would any game, and feed the carcasses to their hounds. The inoffensive and rather feeble-bodied Negritos were treated as beasts of venery, which could be hunted without danger and furnished plentiful supplies of dog's meat, costing the sportsman nothing, not even a pang of

conscience, only the price of a cartridge. (Cf. Schaafhausen, in The Anthropological Review, London, 1869, p. 368.)

More recent and even more revolting exemplifications of this tendency to relapse in barbarism are the atrocities committed by Major Barttelot, and the conduct of Mr. Jameson, of Stanley's Emin-Relief Expedition, who purchased a young negro girl and gave her to a horde of cannibals in order to make sketches from life of the manner in which she was torn in pieces and devoured.

There are also instances on record of Englishmen, Dutchmen, and Frenchmen who in their warfare with Indians adopted from their savage foes the custom of scalping and torturing their captives. In fact, as Waitz has shown in his Anthropolgy (iii, 174), there is scarcely a vice of barbarous tribes which Europeans when removed from the restrains of civilization have not practiced. In the South Sea islands they have in some cases become anthropophagous.

Here we are suddenly brought face to face with the depressing fact that men, who are heirs to ages of intellectual culture and armed with all the powers and possibilities of good and evil which modern science has put into their hands, yet relapse morally to the level of rude cave dwellers and contemporaries of the mammoth in making their superiority of mental endowment and material equipment minister to deeds and passions worthy of the lowest stage of barbarism.

All emigration to wild regions is, in a greater or less degree, atavistic in its effects, and, by loosening or removing the many leading strings of association by which the average man is kept in an upright position and a straightforward course, lets him fall back and retrograde, and thus tends to bring him nearer to his flint-chipping neolithic ancestor. It throws each individual upon his own ethical resources by releasing him from the constant though hardly conscious social pressure of an environment which is the resultant of long periods of human progress, and by which alone the masses of so-called civilized nations are prevented from relapsing into the original condition of the race.

Happily, however, such extreme cases of moral reversion as those of the early emigrants to Australia and the recent explorers of Africa are only sporadic, and the ubiquity of humane and enlightened public opinion arising from greater frequency and rapidity of international intercourse, and causing its immediate influence to be felt in the remotest and roughest border lands of savage and civilized life, will render them still rarer in the future. The telegraph and the telephone are making it daily more difficult and will eventually make it impossible for the most pushing pioneer wholly to lose communication with the advancing body of organized forces behind him, or to break away from

the control of that community of impulses and purposes, and that consensus of moral ideas and perceptions, which we call public conscience. This influence is beginning to penetrate even the darkest regions of Central Africa and to protect the unknown barbaric tribes against the ravages of Arab slave traders and the arbitrary authority of European adventurers. Each nation that joins in this combined movement is doubtless seeking, first of all, to further its own commercial and colonial interests; but it suffices as an illustration of the prevailing spirit of the age that the basis on which they profess to unite is the broad principle of a common humanity.

THE SLEEP OF MOLLUSKS.

By CHARLES T. SIMPSON.

IT is probable that the sleep or dormant period which mollusks share in common with many other organic beings is brought on not merely by the exigencies of climate, but that it is more or less necessary in building up the wasting physical powers. All organized beings seem to require rest in some form or other. If plants, whether from the tropics or temperate regions, are kept in hothouses, they will not grow the year round, and when forced to do so soon become sickly or die outright.

With the mollusks this sleep in many cases may be prolonged indefinitely, often without the slightest apparent damage, and under some conditions which seem really astonishing.

In the sea the clams (*Venus* and *Mya*) have rest periods, during which they sink more deeply into the mud and retreat from the fisherman; the tritons, murices, and ranellas form a shelly growth and mark their seasons of repose by a thickening of the aperture called a *varix*, which is sometimes guarded by spines or knobs. The littorinas, which are amphibious, pass most of their time on grass or sedges at the edge of the sea in the colder regions and high aloft on mangrove or other trees in the tropics, only occasionally going into the water to moisten themselves. Tryon tells of some West Indian species which survived over a year in his cabinet, and of others that lived for months in the dry air of Philadelphia, though they exhibited but little activity; and the writer has kept specimens of the nearly allied *Tectarius* alive in his collection for nearly two years.

Most of the fresh-water species of mollusks pass a period of hibernation in cold climates or æstivation in the tropics, and many of them are wonderfully tenacious of life when withdrawn from the water. In June, 1850, a living pond mussel was sent to Dr. Gray from Australia which had been kept out of water more

than a year, and instances of the survival of unios without moisture for long periods are not rare. While living in south Florida I discovered a colony of unios in a small drain that ran through the pine woods and which only contained water during the rainy season—some three months in the year. Thousands of these mussels were found in the channel among bulrushes, buried vertically an inch or so below the surface in nearly dry soil, with the anterior end downward, and the slightly moist, sandy banks in many places were full of them. The colony extended some ten or a dozen yards along this drain; not a specimen could be found either above or below this space, and the species was not found in the little stream into which it emptied.

A lot of these unios were taken home and laid in the garden, where they remained more than three months wholly unprotected from the hot autumn sunlight during the dry season, and when opened a number of them were found to be alive. Yet ordinarily the want of water causes the *Unionidæ* to speedily die. The summer of 1886 was one of the least rainfall ever known in the upper Mississippi Valley, and many streams and ponds went dry that had never been known to be so before. At this time I collected in northern Illinois and Iowa, and in every instance where the water had evaporated I found the mussels dying by thousands, though in many cases the mud was too soft to bear the collector. While collecting in the Indian Territory I visited a large pond near McAllister that had just been drained, and, although the water stood everywhere in pools, yet the *Unionidæ* were apparently all dead and gaping open, and the stench was so horrible that the struggle between duty and comfort was a severe one. For years I have watched the dredging operations in the Potomac at the capital, as the mud was thrown out on the flats, and in every case the mussels were dead before it was firm enough to be trodden on.

I do not believe in building a theory on too slight a foundation of fact, but I am of the opinion that these unios which have been kept dormant for lengthened periods out of water inhabited streams or ponds that were intermittent. The instance I have given in Florida is a good one, and the mussel Dr. Gray received from Australia is no doubt another. The whole island is noted for heat and long-continued droughts, and with scarcely an exception the streams and lakes go dry during the rainless season. Even the Murray River, the largest stream in the country, and ordinarily navigable for hundreds of miles, sometimes ceases to flow altogether.*

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* Other cases in point are known. In the spring of 1887 I collected several specimens of *Anodonta Ferussacciana* in lagoons along the banks of the South Platte River near

The ampullarias or idol shells, a noble genus of tropical pond snails, bury themselves deeply in mud during the dry seasons. They are remarkable for their ability to live without water, having been kept out of it for years, and they are often brought to foreign countries alive in mahogany logs.

Guilding first noticed that the species of the Antilles had a double system of respiration, which was further dilated on by Caillaud, who brought these snails alive from Egypt; and D'Orbigny discovered that they had a distinct pulmonary apparatus in addition to their gills. According to Joly, anodons and viviparas survive freezing, and will reproduce on being thawed out; and no doubt many of the species that live in cold climates are frozen every winter and resuscitated with the return of spring.

It is believed that all shell-bearing land mollusks either hibernate or æstivate according to conditions of climate. Most of the snails close the aperture with a membranous or coriaceous covering, consisting of lime and mucus, which is called an epiphragm. W. G. Binney has thus described the operation: "The animal being withdrawn into the shell, the collar is brought to a level with the aperture and a quantity of mucus is poured out and covers it. A small quantity of air is then emitted from the respiratory foramen, which detaches the mucus from the surface of the collar and projects it in a convex form like a bubble. At the same moment the animal retreats farther into the shell, leaving a vacuum between itself and the membrane, which is consequently pressed back by the external air to a level with the aperture or even farther, so as to form a concave surface, where, after becoming desiccated and hard, it remains fixed. These operations are nearly simultaneous, and occupy but an instant." As the winter advances the snail withdraws deeper and deeper, shutting itself out by other epiphragms, like a retiring army covering its front by breastworks as it retreats, until sometimes it has made no less than half a dozen, one within the other. With the snails such as ours, that inhabit moist wooded districts, this protecting wall is thin and nearly transparent, while in those of arid regions it is thicker and often calcareous. Some of the large helices of south Europe secrete a somewhat shelly epiphragm resembling the coating of a turtle's egg, convex externally, with the edge turned in and roughly cemented to the aperture of the shell. In this condition, if not resuscitated by moisture, the snails will remain alive for an indefinite period. Woodward tells of a desert snail (*Helix deser-*

Brule, Nebraska, the stream at that time being at an ordinary stage of water. These were kept in a dry shed some two weeks, and the shells became badly cracked by the dry air, yet at the end of that time when opened they were alive. In summer the river becomes so dry that the sand from its bed is blown about the adjoining country.

torum) which, after being glued to a tablet for four years in the British Museum, was noticed to have discolored the paper of its label, and on being put into warm water it revived; and Dr. Stearns kept a *Helix Vietchi* from Cerros Island, Lower California, alive six years without food.* Many other such cases are known.

Strangely enough, the slugs undergo no such period of hibernation, as they only cease activity in temperate climates during the coldest weather, and when a warm spell occurs in winter they are thawed out into new life. It is indeed curious that these naked fellows should be so much more hardy than their relatives, who wear their great overcoats of shells into which they can wholly retreat, but so it is. *Binneya,* a Mexican snail, whose shell is not large enough to cover its body, attaches itself to a spot where it æstivates and forms a parchmentlike epiphragm from the edges of the shell to the place of attachment, and when it returns to activity often carries with it this queer addition to its house. Most snails dissolve this when they awaken from their long sleep.

Nature has kindly relieved the operculated land snails from the trouble of making this protection, and when the time for retiring arrives they simply retreat into the shell and close the door behind them. In this condition they are "not at home" to any callers. The long winter's sleep proves disastrous to many of the snails, and in the spring quantities of dead shells will be found huddled together in hollow trees, under rocks, and in their crevices, or buried beneath the leaves and ground with a few survivors among them. Why they thus assemble together to hibernate is difficult to tell, unless it is because "misery loves company."

The succineas are a somewhat amphibious family of air-breathers, and on the approach of winter often crowd together into tussocks of grass or rushes by the edges of streams and ponds. In eastern Colorado and western Nebraska I have counted from two hundred and fifty to three hundred of them thus tucked snugly away in a single tuft of grass. It is indeed fortunate for them that they are wrapped in unconsciousness during the dreary winter of that shelterless, desolate country, with its howling blizzards and snows drifted wildly over the prairies, and it is marvelous that so large a proportion survives. In that dry region water is a luxury that even a fresh-water snail can not always afford; hence their shells are found strewed over the highest table lands, miles horizontally and hundreds of feet vertically from moisture; and I have gathered numbers of them in

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* For an account of this, see a paper On the Vitality of Certain Land Mollusks, by R. E. C. Stearns, Proceedings California Academy of Sciences, October 18, 1875.

winter under projecting rocks high upon the bluffs of the South Platte River.

In the tropics the process of æstivation is analogous to hibernation, but there is not so complete a cessation of the functions. The same epiphragm is made, and the rest is taken for the same purpose—to avoid the vicissitudes of climate; only in this case it is to escape drought instead of cold. And sometimes the same gregarious habit is observed, and the snails crowd in closer than the occupants of a cheap lodging house. On some of the west Florida keys I have seen *Helix Carpenteriana* æstivating under grass and logs in such vast numbers that one might scoop them up by the quart; and in the Maritime Alps I have found other species of the land snails piled together by hundreds in hollows of limestone cliffs during the dry season. The strophias either cling to the stems of low bushes or lie at their roots, as do many species of *Bulimulus*, often in great numbers.

The arboreal species firmly attach themselves to the bark of the trees on which they live and on whose foliage they subsist, and form a solid epiphragm of the consistence of sole leather.* On the lower part of Florida and on the keys the magnificent *Orthalicus* and *Liguus*, the latter gaudy with bands of yellow, brown, and green, the former a soft cream color, with markings of jet black and brown, live often on such trees as the Jamaica dogwood (*Piscidia erythrina*) and the *Bursera*, which shed wholly or in part their leaves during late winter and spring, the dry season. The sight of one of these trees without foliage, and loaded with this strange, glittering fruit, is enough to thrill the heart and stir the blood of any collector, and I shall never forget my first experience with them at Cape Sable. In my eagerness to possess the beautiful things I broke several specimens, as the epiphragm adhered so firmly that the shell crushed before it would loosen, and I could only save them by cutting away the bark.

One wonders why these snails so freely expose themselves during æstivation, when they are utterly powerless to escape from their enemies. Many of these trees, which were full of them, were isolated more or less and were without foliage, and every shell could be seen hundreds of feet away. That they have enemies I discovered afterward as I wandered broken-hearted among the thick scrub of Key West to find quantities of fresh broken *Orthalicus* lying on the ground, but not one alive. Many of them appeared as though a hole had been picked in them by birds large enough to get out the snail and utterly ruin the shell. In this case death came swiftly and painlessly, no doubt, while they were

* The epiphragm of *Orthalicus zebra* is admirably figured and described by Fischer and Crosse in Mission Scientifique au Mexique et Amérique Centrale.

wrapped in sleep. Such is the summer repose or æstivation of the tropical tree snails. For months of bright, sunshiny weather they cling motionless, perched aloft on their favorite trees that at once are home and food for them, firmly attached by a leathery epiphragm that neither sun nor rain nor wind, or anything but themselves, can dissolve; and on the coming of the first showers of the rainy season they awaken to new activity and life.

WASTE PRODUCTS: COTTON-SEED OIL.

By FREDERIC G. MATHER.

IT has been stated that if the waste products of the world had been saved they would sustain the present population for more than a hundred years. Foreign countries give more attention than America to saving the waste. But as the population of the United States increases, and as processes of manufacture are developed, discoveries are made which turn the waste of former products into useful articles of commerce. Glycerin, wood acid, crude petroleum, and even the fine dust from anthracite coal have an importance to-day that they did not have formerly.

Cotton-seed oil is a most conspicuous instance of an article once thrown aside as a nuisance. Originally it was only a by-product in the manufacture of meal from the seed; and even after it was discovered that meal could be made, it was a question what should be done with the oil.

That question has been answered in various ways. What was garbage in 1860 was a fertilizer in 1870, cattle food in 1880, and table food and many things else, in 1890. A small quantity of the oil is made in England, but it is inferior to the American article because the seed comes from Egypt or India. The American cotton parts with its fiber more readily. The best oil is made from seed belonging to the Southern upland cotton, that from the seaboard having a darker color. The exports are chiefly from New York and New Orleans, and the greater part goes to France, Italy, and the Netherlands. There was a constant increase of exports between 1871 and 1884, when over 6,000,000 gallons, valued at $2,600,000, were exported. Since 1884 the export has rapidly declined, only 2,000,000 gallons, worth $1,300,000, being exported of late years, because the demand in the United States has increased.

Nine tenths of the American product enters into the composition of foods, chiefly for salad and cooking oils and for the making of refined lard. The latter use is the most important of all. Nearly forty years ago the oil was mixed with lard for use in cold

climates so that the stiffening point would be several degrees lower. Lard was also prepared with this oil for the Israelites, whose religion does not permit the use of any product of the hog. The refined lard of to-day is made of refined packer's lard, pure dressed-beef fat, and pure refined cotton-seed oil. The consistence of the beef fat is overcome by the oil. Three fourths of the lard in use to-day contains from ten to twenty-five per cent of the oil, and nearly all of it is sold as oil-lard. It has been attacked by producers of hog lard, but investigations have shown that the new lard is quite as wholesome as the old.

Table oil often bears the brand of olive oil when it is really cotton-seed oil mixed with a small proportion of the olive. Sometimes the oil is taken to France and Italy and mixed there, but more often the mixture is made in this country. So closely is olive oil imitated, both as to taste and color, that only an expert knows the difference. In the earlier days of making cotton-seed oil the white oil brought a higher price than the yellow; but today the yellow oil is the more expensive. Cheaper processes of manufacture have lowered the price and encouraged the use of the yellow oil in making a substitute for butter.

Cotton oil ranks next to sperm oil and above lard oil for illuminating purposes, and it may be burned in any lamp used for either. Mixed with petroleum, it increases the freedom of burning; but this requires a change in the wick. As a lubricating oil cotton-seed is useless, because it is half waý between the drying and the non-drying. For the same reason it can not be used for paints, for wood filling, or for leather dressing. It has some use as a substitute for vaseline and similar products. The oil enters into the production of laundry and fancy soaps and soaps for woolen mills. The American sardines, properly known as young shad and herring, are put up with this oil, and the use of it extends so far that nearly all the real sardines of Europe are now treated in the same way. The oil forms an emulsion in medicine and a substitute for cod-liver oil. On the market the crude oil is known as either prime, or off quality, or cooking. There are also the white summer, the yellow winter, and the white winter. All these, except the crude, bring an average of about fifty cents a gallon in the wholesale market. After the oil has left the seeds, they become food for stock in the shape of oil cake, while the ashes from the hulls make a fertilizer for root crops.

The first attempt to extract oil from cotton seed was made in Natchez, Miss., in 1834. The machinery of the mill was of the most primitive kind, the pressure being given by wedges. Failure attended this effort, and also an effort in 1852 with improved machinery. In 1855 cotton seed began to have a commercial value. Small mills were established, and the prospects for devel-

oping the industry were good until the breaking out of the civil war cut off the supply of seed. Directly after the war, in 1866, there were only seven mills in the whole country. Three of them were in New Orleans, one in Providence, one in Cincinnati, one in Memphis, and one in New York. In 1870 there were twenty-six mills; in 1880, forty-five; and in 1890, two hundred and twenty-five—all but two being in the Southern States, as follows: Alabama, thirty; Arkansas, twelve; Florida, three; Georgia, thirty-nine; Louisiana, fifteen; Mississippi, twenty-three; North Carolina, twenty; South Carolina, thirty-four; Tennessee, twenty; Texas, twenty-seven. The highest capacity of any of the mills is 320 tons daily; and for all the mills, 7,636 tons daily, or 2,367,160 tons annually. None of them are operated on full time, and most of them run only three or four months during the height of the cotton season. The mills are of all sizes, and they range from $5,000 to over $250,000 in value.

The output of cotton-seed products was valued at $600,000 in 1860, $2,205,000 in 1870, $7,691,000 in 1880, and nearly $22,000,000 in 1890. Since that date the product has fallen off. The details for 1890 were: 28,000,000 gallons of crude oil; 17,000,000 pounds of cotton batting; 283,000 tons of oil cake; 378,000 tons of hulls, ash, soap-stock, and other by products; and $2,853,000 of enhanced value in refining the oil and manufacturing the soap. The Southern States produced 2,870,417 tons of cotton seed in 1880, of which barely one eighth was crushed in the mills. The yield of seed during the past five years has been as high as 3,600,000 tons; but only one fifth of it reached the mills. The American Cottonseed Oil Company, formerly known as the Cotton Trust, owns the entire capital stock of ninety-five factories, a small portion of which are not in operation. The factories include not only crude-oil mills, but mills for the production of fertilizers, soap, and the other products. The total business for the year ending November 1, 1889, the best in the history of the mills, was about $25,000,000. An improved method of crushing gave better results than for any previous year. At first the oil was transported from the mills in barrels, but now a great saving is effected by the use of tank cars.

When the season is not dry the seed is rich in oil, and it yields readily thirty-five or more gallons to the ton. An unfavorable season reduces the yield to thirty-one gallons. When the seed is well stored and properly ventilated, it will keep for a year; it is liable to become rancid in the hold of a vessel. If stored long in bulk, it becomes superheated and liable to spontaneous combustion. These facts prevent exportation in large quantities. The cotton plant yields an average of nine hundred and fifty pounds of seed to each bale of cotton. The price of seed has been as high

as seventeen dollars a ton, but there is no profit to the millers if they pay much over twelve dollars. A sharp competition among them led to the forming of an association of the mills in 1878, which was the forerunner of the American Cotton-seed Oil Trust. The Southern States are now divided into districts, each one supplying certain mills, and keeping a uniform price for the seed.

The bulk of the supply is obtained from plantations immediately upon the Southern rivers, because the seed can be transported at little cost. The mills are also located upon the rivers. Once landed at the mills, the seed is conveyed in an elevator to a screen, or cylindrical sifter, where it is shaken until it is free from dust and sand. Then it is blown against another screen to remove stones, iron, and other foreign substances that might injure the rollers. A second elevator carries the seed to the loft, where another sifter separates the seed proper from the bolls or outside hulls of the cotton bloom. No matter how close the picking may have been, the bolls still have cotton sticking to them, and they are dropped into a gin to remove the lint. This is known as "crapo cotton," the only variety of linter produced in the mills. The seed having fallen through the screen, is carried along another screen or gutter directly over the gins. They drop through holes in the screen upon the gins; but when the box above the gin is full the hole is closed automatically, and the screen carries the seed forward to the next box, thus keeping all the boxes full. The gins differ from cotton gins in having one hundred saws instead of sixty. The saws are but half an inch apart and the teeth are very firmly set. The problem of wholly removing the lint, save by chemical process, has not yet been solved.

Once thoroughly separated from all foreign substances—dust, bolls, and cotton—the seed is conveyed to the roller, a revolving cylinder containing twenty-four knives and four back knives, which cuts the hulls from the kernels. This process was formerly carried on by grindstones. The hulls go upstairs, where they are again treated to find such kernels as may still be clinging to them, after which they are sold or used as fuel in the furnace of the mill. Only half of them are needed for this purpose, the other half being sold as food for cattle. The ashes of the hulls make an excellent lye for soap or for the refining of the oil. The kernels are conveyed to rollers, where they are crushed very fine. They are thence removed to the heaters, being agitated all the time so as to give an equal exposure and allow the oil to be more readily extracted. The kernels are then placed in woolen bags packed between horse-hair mats, backed with leather, and having a fluted surface inside to allow the oil to escape more freely. The hydraulic pressure, furnished by the oil itself instead

of by water, is from one hundred and fifty to two hundred and fifty tons.

The bags are in the press about fifteen minutes, the oil running out and the dry kernels remaining behind in a solid cake —the oil cake of commerce. This product is of a rich golden color, quite dry, and of a sweet and oily taste. When used for food it is ground to the consistence of corn meal, and it is known as cotton-seed meal. A comparison of the number of pounds of flesh produced by several kinds of food is as follows: Cotton-seed cake, forty-one pounds; bran, thirty-one pounds; peas, twenty-two pounds; corn, twelve pounds; rye, eleven pounds. The number of pounds of fat produced by the several foods are these: Cotton-seed cake, fifty-seven pounds; bran, fifty-four pounds; peas, fifty pounds; corn, sixty-eight pounds; rye, seventy-two pounds; hay, fifty pounds. It is claimed that cotton-seed cake fed to cows gives a rich and plentiful supply of milk.

The oil, having been pumped into the oil room, is treated with caustic soda and constantly stirred. A deposit falls to the bottom of the kettle and the refined oil is turned off. It averages about eighty-two per cent of the crude oil. The deposit, known as soap stock, sells readily to soap manufacturers, or it is used by the mill itself in the manufacture of soap. Much of it is sent to foreign countries. The oil is occasionally refined over again to remove wholly a slightly bitter flavor of the seed which reduces the culinary value.

It will be noticed that the products of the seed are—(1) oil, both the crude and the refined; (2) oil cake; (3) lint; (4) hulls; (5) soap stock; (6) glycerin. One gallon of crude cotton-seed oil will yield three pounds and a half of glycerin, but thus far only a small amount has been made. The use of the seed for these several purposes has been of great benefit to the Southern States. Their output is constantly increasing, while the supply of petroleum in the oil fields of Pennsylvania and elsewhere appears to be decreasing. The world was greatly excited when petroleum was discovered. But the discovery of cotton-seed oil has been so gradual that the importance of it has not been realized until lately. This brief statement of what is being done to-day with an article that was going to waste a generation ago must lead every student of economy to ask, "Are there not other waste products of the present time that will be used a generation hence, and thus not only increase the comfort of living but also decrease the expense?"

ANCIENT AND MEDIÆVAL CHEMISTRY.

By M. P. E. BERTHELOT.

CHEMISTRY is a modern science, constituted hardly a century ago; but its theoretical problems were discussed and its practices put in operation during all the middle ages. The nations of antiquity were already acquainted with them, and their origin is lost in the night of primitive religions and prehistoric civilizations. I have described elsewhere the first rational attempts to explain the chemical transformations of matter, and purpose now to speak of the chemical industries of the ancient world, and their transmission to the Latins of the middle ages. The story is of interest as showing how the cultivation of the sciences has been perpetuated in the material line by the necessities of their adaptations, through the catastrophes of invasions and the ruin of civilization. Only the total extermination of populations, such as was at times practiced by the Mongols and the Tartars, could completely destroy this cultivation. But such horrors as those perpetrated by Tamerlane have been of rare occurrence.

From the most remote times man has applied chemical operations to his necessities, performing them for metallurgy, ceramics, dyeing, painting, the preservation of food, medicine, and the art of war. While gold and sometimes silver and copper existed in the native state, and required only mechanical preparation, lead, tin, iron, and often copper and silver, had to be extracted from their usual minerals by very complicated artifices. The production of alloys necessary for the fabrication of arms, money, and jewels is also an essentially chemical art. The study of the alloys used in goldsmiths' work gave rise to the prejudices and frauds of alchemy, as is proved by the testimony of an Egyptian papyrus preserved in the Leyden Museum, and of the writings of the Grecian alchemists.

The art of preparing cement, pottery, and glass likewise depends on chemical operations. The workmen who dyed cloths, clothing, and tapestries in purple or other colors, an industry practiced first in Egypt and Syria and then in all the Grecian, Roman, and Persian world, not to speak of the extreme East, employed highly developed chemical manipulations; and the cloths found on the mummies and in the sarcophagi attest their perfection. Pliny and Vitruvius describe in detail the production of colors, such as cinnabar or vermilion, minium, red chalk, indigo, black, green, and blue colors, vegetable as well as mineral, performed by painters. The chemistry of alimentation, fruitful in resources and in frauds, was next practiced. The art was known

of accomplishing at will those delicate fermentations which produce bread, wine, and beer, and which modify a large number of foods; also of falsifying wine by the addition of plaster and other ingredients. The art of healing, seeking everywhere for resources against diseases, had learned to transform and fabricate a large number of mineral and vegetable products, such as sugar of poppy, extracts of nightshades, oxide of copper, verdigris, litharge, white lead, the sulphurets of arsenic and arsenious acid; remedies and poisons were composed at the same time, for different purposes, by doctors and magicians. The manufacture of arms and of inflammatory substances—petroleum, sulphur, resins, and bitumens—had already, anciently as well as in our own time, drawn upon the talents of inventors and given rise to formidable applications, especially in the arts of sieges and marine battles, previous to the invention of the Greek fire, which was in its turn the precursor of gunpowder and of our terrible explosive matters.

This rapid review shows how far advanced in the knowledge of chemical industries the Roman world was at the moment when it went to pieces under the blows of the barbarians. But the ruin of the ancient organization came about by degrees: while high scientific study, hardly accessible to coarse minds, ceased to be encouraged, and was gradually abandoned; while the Greek philosophers, knocked about between the religious persecution of the Byzantine emperors and the indifferent disdain of the Persian sovereigns, no longer trained pupils; while the great names of Grecian physics, mathematics, and alchemy hardly passed the time of Justinian, it is still certain that the necessity of professions indispensable to human life, or sought out by sovereigns and priests, could maintain and did maintain effectively most of the chemical industries.

Proofs of various kinds can be brought up in support of these reasonings. Some are drawn from the examination of the monuments, arms, potters' and glass ware, cloths, gems and jewels, and art objects of every kind which have come down to us. Such examination furnishes, in fact, incontestable results, provided the dates of the objects are certain, and they have not suffered restoration. Respecting the date, we can not exercise too much prudence and distrust, whether we are examining buildings or objects in museums. The accounts and descriptions by contemporary historians furnish other data, but less precise, for it is better to have the object in hand than the description. They have the advantage, however, of giving us indications independent of the ulterior progress of the industry. We have a still surer and more exact class of data than the chronicles in the technical treatises and works concerning arts and trades which have come down to us, whenever those treatises have an ascertained

date, even were it only the date of their copies. This source of facts is already known as to antiquity. It is not wanting as to the middle ages, although it seems to have till now escaped the erudite persons who have written the history of science, and it permits us to reconstitute that under a new form and with a new precision. By the aid of those documents I shall attempt to show, concerning myself especially with chemical industries, what knowledge, practical or theoretical, subsisted after the fall of ancient civilization, and how the traditions of the shop maintained those industries, almost without new inventions, but at least at a certain level of perfection.

The history of physical science in antiquity is very imperfectly known to us. There existed then no methodical treatise for the purpose of teaching, such as we have in the principal civilized states. Hence, except as to the medical sciences, we have only insufficient notions respecting the processes employed in the arts and trades of the ancients. The experimental method of the moderns has associated those practices into a body of doctrines, and has shown close relations between them and the theories for which they served as basis and confirmation. This method was almost unknown to the ancients, at best as a general principle of scientific learning. Their industries had little connection with theories, excepting in measures of length, surface, or volume, which were deduced immediately from geometry and in goldsmiths' receipts, which were the origin of the theories, partly real and partly imaginary, of alchemy. It has been even asked if industrial formulas were not formerly preserved by purely oral tradition and carefully held back for the initiated. Some scraps of the traditional lore may have been transcribed into the notes which have been used in the composition of Pliny's Natural History and the works of Vitruvius and Isidore de Seville, not without a considerable mixture of fables and errors. But a more thorough examination of the works that have come down to us from antiquity, a more attentive study of the manuscripts, at first neglected because they did not relate to literary or theological studies or to ordinary historical questions, permits the affirmation that they were not so. We are all the time discovering new and considerable documents which show that the processes of the ancient industrials were then, as now, inscribed in workmen's note-books or manuals intended for the use of the tradespeople, and that they were transmitted from hand to hand from the most remote times of ancient Egypt and Alexandrine Egypt, to those of the Roman Empire and the middle ages. The discovery of these note-books offers all the more interest because the use of the precious metals with civilized peoples goes back to the highest antiquity; the technique of the ancient goldsmiths and jewelers is not revealed to us all at once except

by the examination of the objects that have come down to us. The earliest precise and detailed texts describing their processes are contained in an Egyptian papyrus found at Thebes, and now in the museum at Leyden.

This papyrus is in the Greek language and dates from the third century of the Christian era. In my translation of it, comparing parts of it with phrases in the works of Pliny and Vitruvius on the same subjects and with Greek alchemistic works of the fourth and fifth centuries, I have reconstituted a whole science, ancient alchemy, till now misunderstood and uncomprehended, because it was founded on a mixture of real facts, profound views on the unity of matter, and chimerical religious fancies. These practices and theories had a still larger bearing than the working of metals. The industries of the precious metals were in fact associated at that epoch with those of the dyeing of cloths, the coloring of glasses, and the imitation of precious stones, all guided by the same tinctorial ideas and executed by the same operators.

Thus alchemy and the chimerical hope of making gold were derived from the goldsmiths' artifices for coloring metals. The pretended processes of transmutation which were current during the middle ages were in their origin only tricks for preparing alloys of inferior standard—that is, for imitating and falsifying the precious metals. But, by an almost invincible attraction, the operators addicted to these practices did not hesitate to imagine that one could pass from the imitation of gold to its effective formation—especially if he had the aid of the supernatural powers, invoked by magical formulas.

At any rate, it was not known till now how these practices and theories passed from Egypt, where they were flourishing toward the end of the Roman Empire, into the West, where we find them in full development from the thirteenth and fourteenth centuries in the writings of the Latin alchemists and in the laboratories of the goldsmiths, dyers, and makers of colored glass. Their renascence was generally attributed to translations of Arabian works made at that epoch. But, without assuming to deny the part played by the Arabian books in the renascence of the arts and sciences in the West, in the period of the Crusades, it is no less certain that a continuous tradition subsisted in the professional recollections of the arts and trades from the Roman Empire till the Carlovingian period, and later—a tradition of chemical manipulations and scientific and mystical ideas. In fact, in pursuing my studies of the history of science, I have met, in the examination of the Latin works of the middle ages, certain technical manuals which were related most directly with the metallurgical treatises of the Greco-Egyptian alchemists and goldsmiths. I purpose to

demonstrate here this correlation, which nobody has till now pointed out.

It is known that the receipts of therapeutics and *materia medica* have been preserved in a parallel way by practice, which has never ceased, in the Receptaries and other Latin treatises; these treatises, translated from the Greek during the period of the Roman Empire, and compiled in the first and second centuries, passed from hand to hand, and were copied frequently during the earlier portions of the middle ages. The transmission of the military arts and of fire-producing formulas, particularly, was carried on from the Greeks and Romans through the barbarous ages. In short, the necessity of the applications has always caused the subsistence of a certain experimental tradition of the arts of ancient civilization.

The oldest technical treatises in Latin of the middle ages on subjects in chemistry with which we are acquainted are the Formulas for Dyeing (*Compositiones ad tingendo*), of which we have a manuscript written toward the end of the eighth century, and the Key to Painting (*Mappæ clavicula*), the oldest manuscript of which is of the tenth century. The Formulas for Dyeing is not a methodical work, but a book of receipts and documents collected by a dyer for use in his art and intended to furnish him with working processes and information concerning the origin of his prime materials. It concerns such subjects as the coloring or dyeing of artificial stones for mosaic work; gilding and silvering and polishing them; making of colored glass in green, milky white, various shades of red, purple, yellow—the colors being both deep and superficial, and often brought out by the aid of simple varnishes; coloring of skins in purple, green, yellow, and various reds; dyeing of woods, bones, and horns; notices of minerals, metals, and earths used in goldsmiths' work and painting. Curious ideas are set forth on the function of the sun and of heat, peculiar to certain warm earths in the production of minerals endowed with corresponding virtues; while a cold earth produces minerals of weak quality. This reminds us of the theories of Aristotle on dry exhalation as opposed to moist exhalation in the generation of minerals—theories that made an important figure in the middle ages. The author distinguishes a feminine and light lead mineral as against a masculine and heavy mineral; a distinction like that mentioned by Pliny between male and female antimony, the male and female blue of Theophrastus, and many others. Minerals were continually likened in the chemistry of the middle ages to living beings.

We read likewise in this work of articles developed in certain operations, such as the extraction of mercury, lead, the roasting of sulphur, preparations of white lead with lead and vinegar, of

verdigris with vinegar and copper—already described by Theophrastus and Dioscorides—of cadmies, impure oxides of lead and zinc, of burned copper (*aes ustum*), of litharge, of orpiment, of artificial cinnabar, etc. The writer mentions a few alloys, such as bronze, white copper, and gold-colored copper—a subject often treated of by the Greek alchemists, who passed from it to the idea of transmutation. The name of bronze (*brundisium*) appears for the first time. While its origin has been the subject of controversy among philologists, the accompanying facts given in the text show that bronze was in the beginning an alloy made at Brundisium for the manufacture of the mirrors of which Pliny speaks. The preparation of parchment and of varnish, the fabrication of vegetable colors for the use of painters and illuminators, and their employment on walls, wood, canvas, etc., in encaustic or with isinglass, are the subjects of separate articles.

A group of formulas for gilding follow: gilding of glass, wood, skins, clothing, lead, tin, and iron; and the preparation of golden wires, processes for writing in golden letters (chrysography) on parchment, paper, glass, or marble. Then come silver foil, tin foil, and processes for reducing gold and silver to powder, in which mercury and verdigris were employed—the powder obtained by amalgamation being employed in processes for silvering and gilding. The process has played its part in political economy; for it has been used to assist the passage of gold and silver from one country to another, in spite of the prohibition of the exportation of the precious metals.

The author goes on to say: "We have described everything relative to tinctures and decorations; we have spoken of the substances which are employed in them—stones, minerals, salts, and herbs; we have shown where they are found; whence are got resins, oleoresins, and earths; what are sulphur, black water, salt waters, glue, and all the products of wild and cultivated plants, domestic and marine; beeswax, axunge, all fresh and acid waters; among woods, the pine, fir, juniper, and cypress, . . . acorns and figs. Extracts are made of all these things with a water made of fermented urine and vinegar, mixed with rain water."

These enumerations and descriptions mark the nature of the knowledge sought by the writer, and preserve the trace of ancient treatises on drugs and medicines, similar to those of Dioscorides, but more especially devoted to industry. Unfortunately, we have here hardly else than titles and summary indications, such as would figure in a dyer's scrap-book, placing one after another indications drawn from different authors. Many of the specific names found in the treatise are wanting in the most complete dictionaries. The terms salt, fresh, and acid waters, water formed of fermented urine and vinegar, deserve special notice

because they point to the beginning of chemistry by moist processes. They figured in Pliny and the ancient authors, to the same purposes. The liquids are always natural ones or the results of the mixture of such, before or after spontaneous combustion. There is no mention of the active liquids obtained by distillation, which were called divine or sulphurous waters, and held an important place with the Greco-Egyptian chemists, and became the origin of our acids, alkalies, and other agents; they had not yet entered into industrial use, and are seldom met with previous to the fourteenth century.

The group of receipts transmitted by the formulas for dyeing, passed into a more extended collection called the Key to Painting, of which exist a manuscrip of the tenth century in the library of Schlestadt and one of the twelfth century, of which an edition was published in 1847 by Mr. Way. The former manuscript is free from all Arabian influence, which has caused the interpolation of five additional articles in the second one. The work contains a treatise on the precious metals comprising now a hundred articles, about half of the original work, the other half having been lost, and a treatise on recipes for dyeing, representing principally those in the Formulas; together with sixteen articles on military ballistics and fireworks, forming a special group; articles on the hydrostatic balance and the densities of the metals; and industrial and magic recipes, added at the end of the book. The treatise on the precious metals is of great interest because of the striking analogies it presents with the Leyden Egyptian papyrus found at Thebes, and with other ancient works. Many of the recipes are literally translated from these ancient works; an identity proving indisputably the continuous preservation of alchemic practices, including transmutation, from Egypt down to the artisans of the Latin West. The theories proper, on the other hand, did not reappear in the West till toward the end of the twelfth century, after they had passed through the Syrians and the Arabs. But the knowledge of the processes themselves was never lost. This fact is demonstrated by the study of the alloys intended to imitate and falsify gold; for coloring (copper) gold-color; for fabricating gold; for making test gold; for rendering gold heavier; and for doubling gold. The recipes are filled with Greek words that betray their origin.

The object for the most part is simply to make base gold, as, for instance, by preparing an alloy of gold and silver, colored with copper. The goldsmith, however, tried to make this pass for pure gold. Then manufactures of complex alloys which were made to pass for pure gold were made easier by the intervention of mercury and sulphurets of arsenic, the use of which goes back to the earliest times of the Roman Empire. Thus Pliny relates

in a few lines an experiment performed by order of Caligula for fabricating gold with sulphuret of arsenic (or orpiment). There was thus a whole special chemistry, now abandoned, which was conspicuous in the practices and pretensions of the alchemists. A patent has been obtained in our own times for an alloy of copper and antimony, containing six hundredths of the latter metal, which presents most of the apparent properties of gold and is worked in the same manner. Alchemic gold belonged to a family of similar alloys. Those who made it fancied besides that some agents played the part of ferments to multiply gold and silver. Before deceiving other people they deluded themselves. Sometimes the artisan was satisfied to use a cement or superficial action, painting the surface of silver in gold or the surface of copper in silver, without modifying the metals in their thickness. This is what goldsmiths still call giving color. They would even do no more than apply to the surface of the metal a gold-colored varnish, prepared with the bile of animals or with certain resins, as is still done. From these colorings the operator, led by a mystic analogy, passed to the idea of transmutation, in the false Democritus and in the Key to Painting. The author of the last work concluded, for example, with the words, "You will thus obtain excellent gold and fit for the test." The author added, further, "Hide this sacred secret, which should be delivered to no one, nor to any prophet." The word prophet betrays the Egyptian origin of the recipe. It refers to the Egyptian priests, who, according to a passage in Clement of Alexandria on the Hermetic books that were borne with great pomp in the processions, were called prophets.

In further proof of the Greco-Egyptain origin of goldsmiths' recipes contained in the Key to Painting is the existence in the Latin collection of ten recipes—some of the elaborate ones—which are phrased in precisely the same terms in the Greek papyrus in Leyden; the former text being translated from the latter, even to the detail of certain technical expressions, which are still perpetuated in the goldsmiths' manuals of the present. This does not mean that the text transcribed in the Key to Painting was originally translated from the very papyrus that we possess, which was not found till the nineteenth century at Thebes, Egypt; but the coincidence of the text proves that there existed books of secret goldsmiths' recipes transmitted from hand to hand of the tradesmen, which continued through the middle ages, and of which the Key is an example. It was firmly believed in the time of Diocletian that the Egyptians had the secret of enriching themselves by making gold and silver; and in consequence of this belief, after a revolt, the emperor ordered all their books burned. Nevertheless, as we have seen, the formulas did not disappear.

The title of one of the recipes in the old table, "How to make unbreakable glass," deserves to be dwelt upon, on account of the legends and traditions that are associated with it, and which have been perpetuated down to our own time. Unbreakable glass appears to have been really discovered under Tiberius, and gave rise to a legend according to which its properties were amplified and it was made malleable. Tiberius, according to Pliny, caused the factory to be destroyed, for fear that the invention would diminish the value of gold and silver." "If it was known," wrote Petronius, "gold would become as cheap as mud." According to Dion Cassius, Tiberius slew the author. Petronius, who is repeated by other authors, says that he was decapitated, and adds that "if vessels of glass were not fragile they would be preferable to vessels of gold and silver."

These stories relate evidently to the same historical fact, reported by contemporaries, but disfigured by legend; the invention was probably suppressed for fear of its economical consequences. It is very curious to find it mentioned in the goldsmiths' recipes of the middle ages, as if the secret tradition had been preserved in the shops. Some of them claimed that glass could be made malleable and ductile and changed into a metal. A process for making glass that will not break has been discovered in our own times, and is announced unequivocally and in definite shape. In truth, malleable glass was not really in question; but even that is not a chimera. Industrial processes for beating and molding glass, based on the plasticity and malleability which it possesses at a temperature near fusion, have been described in late years. An article in the Key to Painting seems to point to a similar process. Real properties, perceived doubtless from antiquity and preserved as shop secrets, gave rise to the legend.

The collection bearing the name of Eraclius or Heraclius is in two parts, of different composition and date. The first part consists of two books in verse, having the character of the writing of the end of the Carlovingian epoch, or of the ninth and tenth centuries. It treats of vegetable colors, of gold leaf, of writing in letters of gold, of gilding, of painting on glass, and of the preparation of precious stones. All the recipes are of ancient origin, a little vague, and without novelty. A book in prose is more compact and precise. It was added later by a continuator, toward the twelfth century, for there is a discussion in it of the coloring of Cordovan leather, and cinnabar, which is red, is called in it azure —a translation of an Arabic word, frequent in the twelfth century, which has given rise to all sorts of misconceptions and confusion with our modern azure blue. It has the stories about malleable glass; and most of the subjects were already treated in the Key to Painting.

The Picture of Different Arts of the monk Theophilus seems to be the work of an author who lived at the end of the eleventh century and beginning of the twelfth. It is more exact and detailed than the work of Eraclius, and is composed of two parts—the first devoted to painting, and the second concerning the making of objects required in worship and the construction of buildings devoted to it. It describes in detail the furnace for melting glass and the manufacture of glass, the making of painted glass and colored earthen vessels, the working of iron, the melting of gold and silver and the working of them, enamel, the fabrication of vessels used in worship—the chalice, monstrance, etc.—organs, bells, cymbals, etc. The facts are curious, for they show that the industry of glass and metals had finally concentrated around the religious edifices. But the chemical technique is the same as that of the other books, though savoring of more modern influences; it brings us directly to the thirteenth and fourteenth centuries, from which period monuments and writings multiply more rapidly down into modern times. The derivation of technical traditions from antiquity becomes less and less manifest as intermediaries multiply and the arts tend to assume an original character.

The facts I have presented deserve our attention as a whole, in view of the course and renascence of scientific traditions. Sciences begin in fact with practice. The first object is to satisfy the necessities of life and the artistic wants that awaken early in civilizable races. But this same practice at once calls out more general ideas, which appeared first among mankind in a mystic form. With the Egyptians and Babylonians the same persons were at once the priests and the men of science. Thus the chemical industries were first exercised around the temples. The Book of the Sanctuary, the Book of Hermes, and the Book of Kemi, all synonymous denominations with the Greco-Egyptian alchemists, represent the earliest manuals of those industries. It was the Greeks, as in all other scientific branches, who gave these treatises a revision freed from the old hieratic forms, and who tried to draw from them a rational theory, capable in its turn, by a similar application, of pushing the practice forward and of serving as a guide to it. But the chemical science of the Greco-Egyptians never rid itself of the errors relative to transmission—which were sustained by the theory of primal matter—or of the religious and magic formulas formerly associated in the East with every industrial operation. Yet when scientific study proper perished with Roman civilization in the West, the wants of life kept up the imperishable practice of the shops with the progress required in the time of the Greeks, and the chemical arts subsisted; while the theories, too subtile or too strong for the minds

of the time, tended to disappear, or rather to return toward the ancient superstitions. In the Key to Painting, as in the Egyptian papyrus and the texts of Zosimus, are mentions of prayers to be recited during the operations; and in this way alchemy remained intimately connected with magic in the middle ages as well as in antiquity.

When civilization began to revive during the Latin middle ages, toward the thirteenth century, in the midst of a new organization, our races took up anew the taste for general ideas, and these, in the sphere of chemistry, were sustained by practices, or rather they obtained their support in the permanent problems raised by them. Thus the alchemistic theories were suddenly revived, with new vigor and development, and their progressive evolution, while improving industry, gradually eliminated the superstitions of former times. Thus was finally constituted our modern chemistry, a rational science, established on purely experimental bases. The science was therefore born in its beginning of industrial practices; it kept course with their development during the reign of ancient civilization; when science went down with civilization, practice survived and furnished science a solid ground on which it was able to achieve a new development when the times and the minds had become favorable. The historical connection of science and practice in the history of civilizations is therefore manifest. There is in it a general law of the development of the human mind.—*Translated for The Popular Science Monthly from the Revue des Deux Mondes.*

SKETCH OF SIR JOSEPH HENRY GILBERT.

ON the 29th of July, 1893, the little village of Harpenden, in Hertfordshire, England, witnessed a rare ceremonial and was stirred by unusual emotions. The presidents of the scientific societies of England were there, with other of the most eminent men of science in the kingdom and foreigners of like standing; while others, their peers, were represented by letters. Mr. Herbert Gardner, M. P. and Minister of Agriculture of the United Kingdom, presided; by his side were the Duke of Devonshire, President of the Royal Agricultural Society; the Duke of Westminster, who, as chairman of the Executive Committee of the Rothamsted Jubilee Fund, might be considered as manager of the business for which the meeting was held; Lord Kelvin, President of the Royal Society; Dr. Michael Foster; Dr. H. E. Armstrong, President of the Chemical Society; Prof. Charles Stewart, President of the Linnæan Society; Sir J. D. Hooker; Sir John

Evans, Treasurer of the Royal Society and Honorary Treasurer of the Rothamsted Jubilee Fund; the Earl of Clarendon, Lord Lieutenant of the County of Herts; Sir John Lubbock, M. P., Trustee of the Lawes Agricultural Fund; Mr. Ernest Clarke, Secretary to the Royal Agricultural Society of England and Honorary Secretary of the Rothamsted Jubilee Fund; representatives of the Société des Agriculteurs de France; and other men whose names are as significant and representative. Letters were read from the Prince of Wales, to whom is given the credit of having originated the celebration; Prince Christian; the Marquis of Salisbury; Prof. Huxley; Sir Gabriel Stokes; M. Tisserand, Director of Agriculture for France; the Association of Experimental Stations in Canada and the United States; M. Pasteur; M. Déhéran, and other foreigners famous in science. These distinguished guests were assembled, and the ceremonies of the day were performed, to do honor to the work of two men—plain farmers, we might correctly call them—who had spent their lives in the study of the best means of improving the yield and quality of agricultural crops—Sir John Bennet Lawes and Mr. Joseph Henry Gilbert.

We have already given, in a sketch of J. B. Lawes, in Volume XXVIII of The Popular Science Monthly, a brief account of the early history of the Rothamsted Agricultural Experiment Station.

It was established by Mr. Lawes on the estate which he entered by inheritance in 1834. He had been engaged for several years in chemical experiments, chiefly with reference to the preparation of drugs. As he wrote to a friend in 1888, he had not thought of any connection between chemistry and agriculture till his attention was attracted by the remark of a gentleman, who farmed near him, that on one farm bones were invaluable for the turnip crop, and on another farm they were useless. A quantity of precipitated gypsum and spent animal charcoal was offered him; he was using much sulphuric acid in his drug experiments; and here he had materials for applying superphosphate and enlarging and extending to the field experiments which he had begun with plants in pots. In 1843 Mr. Joseph Henry Gilbert became associated with Mr. Lawes, and the experiments have been continued since then without interruption under the joint direction of the two. The celebration we have mentioned was held to commemorate the fiftieth anniversary of this connection and of the beginning of the real work of the Rothamsted Station. Both men were entitled to equal honor in remembrance, and both received it in the tributes which were offered.

Mr. Gilbert was born at Hull, August 1, 1817. His father was the late Rev. Joseph Gilbert, and his mother was well known as an author, under the name of Ann Taylor of Ongar. After

going through school he was injured by a gunshot, by which his health was impaired for a time, and he lost the use of one eye. He entered the University of Glasgow, where he gave special attention to chemistry and worked in the laboratory of the late Prof. Thomas Thomson. Next he went to University College, London, where he attended the classes of Prof. Graham and others, and worked in the laboratory of the late Dr. Anthony Todd Thomson. Having spent a short time in the laboratory of Prof. Liebig, at Giessen, and received the degree of Ph. D., he returned to University College, London, and acted as class and laboratory assistant to Prof. Thomson in the winter and summer sessions of 1840–'41, attending other courses in the college at the same time. After this he devoted some time to the chemistry of calico-printing, dyeing, etc., in the neighborhood of Manchester. From 1843, when he became associated with Mr. Lawes at Rothamsted as director of the laboratory, his career has been recorded in the history of that institution; and it is difficult to separate the work of the two, who have co-operated harmoniously and efficiently. The results of their investigations have been published in a series of papers, now numbering more than a hundred, in various journals, among which may be mentioned: The Proceedings and Transactions of the Royal Society, the Journal of the Royal Agricultural Society of England, the Journal of the Chemical Society, the Reports of the British Association for the Advancement of Science, the Journal of the Statistical Society, the Journal of the Society of Arts, etc.; also in official reports and elsewhere.

Dr. Gilbert was elected a member of the Chemical Society in 1841, the year of its formation, and he contributed to the first volume of its memoirs a translation of a paper on the Atomic Weight of Carbon, by Prof. Redtenbacher and Prof. Liebig. He was president of the society in 1882–'83. He was elected a Fellow of the Royal Society in 1860, and in 1867 the council of the society awarded to him, in conjunction with Mr. Lawes, one of the royal medals. He is also a Fellow of the Linnæan Society and of the Royal Meteorological Society. He was President of the Chemical Section of the British Association in 1880. He traveled considerably in the United States and Canada in 1882 and 1884, studying the conditions of the agriculture of these countries. He was appointed Sibthorpian Professor of Rural Economy in the University of Oxford in 1884, and was reappointed for a second period of three years in 1887. He has honorary degrees from the Universities of Oxford, Glasgow, and Edinburgh. He is a life governor of University College, London, an honorary member of the Royal Agricultural Society of England, of the Chemico-Agricultural Society of Ulster, of the Academy of Agriculture and Forestry of

Petrovskoie, and of the Royal Agricultural Society of Hanover; foreign member of the Royal Agricultural Academy of Sweden; and corresponding member of the Institute of France (Academy of Sciences), of the Society of Agriculturists of France, of the Society for the Encouragement of National Industry, Paris, and of the Institut Agronomique of Gorigovtsk. He is also Chevalier du Mérite Agricole, France, and, in conjunction with Sir J. B. Lawes, gold-medalist of merit for agriculture, Germany.

At the celebration of July 29th, separate testimonials, read by the Duke of Westminster, were addressed to the colleagues by the Prince of Wales. To Mr. Gilbert the prince said, offering his congratulations on the completion of fifty years of the joint continuous labors of the two in the cause of agricultural science: "The nature and importance of these labors are so well known that it is needless to dilate upon them; but if the institution of the various investigations has been due to Sir John Lawes, their ultimate success has been, in a great measure, secured by your scientific skill and unremitting industry. Moreover, by your lectures and writings you have been a leading exponent in this and other countries of the theoretical and practical aspects of the researches that have been undertaken at Rothamsted. A collaboration such as yours with Sir John Lawes, already extending over a period of upward of fifty years, is unexampled in the annals of science. I venture to hope for an extended prolongation of these joint labors, and trust that the names of Lawes and Gilbert, which for so many years have been almost inseparable, may survive in happy conjunction for centuries to come."

The address from members of the Royal Agricultural Society to Mr. Gilbert declared that "in the organizing and systematic arrangement and record of the researches conducted at Rothamsted you have had a leading share; and you have there set before us a model of what all work and experimental inquiry should be. Your investigations into the applications of chemistry to the cultivation of crops and the feeding of live stock have been of the highest possible importance to the practical agriculturist, and the sincere thanks of the agricultural community at large are due and are hereby tendered to you for the scientific skill and indefatigable industry which you have brought to bear upon the conduct of the Rothamsted researches. The Royal Agricultural Society of England is proud of ranking you among its honorary members, and it desires to take this opportunity of expressing its indebtedness to you for your ever-ready counsel and assistance, as well as for the many admirable and exhaustive papers which, in conjunction with Sir John Lawes, you have contributed to the society's journal."

The Royal Society's address disclaimed any attempt in any

way to distinguish Mr. Gilbert's share from that of his colleague "in the remarkable work which has, with so much skill and patience, been so long carried on, and, indeed, they know that you would not wish that they should; but they desire to say to you, as they have said to him, that the society is justly proud of your labors. They are glad to bear in mind that the society has been the channel through which most of your more important results have been made known, that for more than thirty years you have been enrolled among the number of its fellows, and they believe they can say that the society has always given you such aid and support as lay in its power. They reflect with satisfaction that the researches at Rothamsted have contributed in a remarkable manner to the advancement of that branch of natural knowledge with which they deal, and your connection with the society gives the president and council, they venture to think, the right to feel something like a paternal pride in the success of an undertaking of which the jubilee marks a stage." The joint address to the two of the Chemical Society recognized the long adherence to the same plan of experiment as evidence of the skill displayed in its inception and as giving to the work its peculiar value, and continued: "While affording guidance to the agriculturist, your researches have elicited information which will ever serve as the foundation of a truly scientific knowledge of the correlation of plant growth and manurial constituents of the soil, and will be of the utmost value in all discussions of the chemistry of plant life. Your researches on the feeding of animals, in like manner, are not only of practical importance, but also shed much light on the processes of animal life." But of even far greater value was the example which their single-minded devotion to the cause of scientific truth and research had afforded to the world. A congratulatory address was received from the Société Nationale d'Agriculture de France.

Sir John Lawes, being called to speak, said that when two persons were joined in marriage they could not part, because they were bound by solemn ties; but the case with respect to himself and Dr. Gilbert was different. Dr. Gilbert could have left him and he could have left Dr. Gilbert at any time during their association. Why had they not done so? Because they had an immense love of the work they were engaged in. Personally, he had delighted in it from the beginning, and had given as much time to it as he could consistently with other duties; but Dr. Gilbert had made it the work of his life. He had been at work not only when he was at home, but had spent what were called his holidays in visiting other countries and places, in putting himself into communication with other bodies, so that he might make his own work more valuable to those at home.

In connection with these remarks it is proper to recall what Mr. Lawes said in 1855, thirty-nine years ago, in his speech at the inauguration of the new laboratory building, erected by public subscription by British agriculturists: "I should be most ungrateful were I to omit to state how greatly I am indebted to those gentlemen whose lives are devoted to the conduct and management of my experiments. To Dr. Gilbert, more especially, I consider a debt of gratitude due from myself and from every agriculturist in Great Britain. It is not every gentleman of his attainments who would subject himself to the caprice of an individual, or risk his reputation by following a science which has hardly a recognized existence. For twelve years our acquaintance has existed, and I hope twelve more years will find it existing." Those "twelve more years" have now increased to thirty-eight "more years," and not the acquaintance only—the close association, too—still exists.

Mr. Gilbert spoke, expressing his gratification at the tributes which had been offered to him, and closed by saying that, however many years were spared to them—and they must necessarily be very few—he hoped they might be able to do something to extend the general knowledge which was the best legacy they could leave to those who would succeed them.

A portrait of Sir John Lawes, by Prof. Hubert Herkomer, representing him as the farmer of Rothamsted, was presented to him, and a silver salver, on which the addresses were deposited, to Dr. Gilbert. A granite bowlder, "turning the scales at eight tons," was set up in front of the laboratory, bearing the inscription, "To commemorate the completion of fifty years of continuous experiments (the first of their kind in agriculture) conducted at Rothamsted by Sir John Bennet Lawes and Joseph Henry Gilbert, A. D. MCCCXCIII." As an additional memorial, forty-four complete sets of the Reports of the Rothamsted Station were presented, at the expense of the nation, to leading public institutions. A few days after the celebration Dr. Gilbert was knighted, "in recognition of his valuable researches for the promotion of agriculture."

A bill is before the British Parliament to prohibit the raising of unsightly erections—having particular reference to advertising structures—to the harm of the rural scenery of Great Britain and Ireland. It applies to fences, gates, posts, hoardings, etc., and to the posting of any printed or written matter, or any picture, so as to be in view from any highway, railway, etc.; but not to such legitimate advertising as is intended to show that the property is to be let or is for sale, or to publish a business that is there carried on. We have a similar law in New York for the protection of natural scenery that might be applied to the appurtenances of property; but who sees to the enforcement of the law we have?

EDITOR'S TABLE.

SCIENCE, ORTHODOXY, AND RELIGION.

JUDGING by a kind of "symposium" we saw lately in a San Francisco paper, the clergy of that city, or at least some of them, seem to think it their duty to keep a watchful eye on the utterances of the professors of science in the neighboring universities, in order that they may raise a voice of warning should anything be said that threatens to conflict with their ideas of theological orthodoxy. As usually happens in such cases, the men who have fallen under the censure of these guardians of the truth are two of the brightest ornaments of the Western scientific world—Prof. Joseph Le Conte, of the University of California, and President David Starr Jordan, of Stanford University. These eminent scientists had not succeeded in "hitting it off" to the entire satisfaction of their clerical critics, and were consequently attacked by the latter with no little acrimony. To offset this manifestation of narrow-mindedness, however, the Episcopalian Church Club of San Francisco, as we learn, gave a dinner to the incriminated professors, at which liberal, kindly, and rational sentiments were the order of the day. It is to this celebration, if we may so call it, that the discussion which we referred to at the outset relates. Prof. Le Conte, who contributes the first paper, predicts that, when the religious world has succeeded in adjusting itself to the doctrine of evolution, as it has already done to various geological and astronomical theories which it once considered very alarming and heretical, religion will only be the stronger because more rational. Prof. David Starr Jordan makes so bold as to say that "science can not demand anything less than absolute freedom of development; it must be free alike from the need of premature decisions and of premature reconciliations." He says, moreover, that whatever be the origin of a doctrine or opinion, science claims the right to set it aside if it is found to be scientifically false or unsound. He declines to accept the dictum that there are three kinds of evolution, theistic, agnostic, and atheistic, and that these must be carefully distinguished. He says there is but one kind of evolution, and that the epithets in question have no application to it, but only to individuals. What he means, evidently, is that the only kind of evolution a man of science as such can believe in is that which reveals itself to him as the result of his investigations. Mr. W. T. Stead, editor of the Review of Reviews, says (writing from Chicago, where he was at the time) that "it will take a good many banquets to evolutionists before the Christian Church can adequately acknowledge the debts which it owes to the man (Darwin) and the school which revivified the popular conception of the living God."

Thus good comes out of evil. The ecclesiastical mind would fain still impose fetters upon scientific thought, but whenever it makes any open attempt to do so, it is sure in these days to meet with repulse. If our religious teachers would but believe it, there is an ample field open to them for instructing and benefiting mankind without making any attempts to restrict scientific investigation or the enunciation of scientific doctrines. It is theirs to interpret to their fellow-men—in so far as they may be sufficient for the task—their deepest relations to the universe in which they live. The hygienist may tell us how to maintain our physical health, the sociologist how to govern ourselves as members of society, the publicist or political

economist how we may advance our own material interests or contribute to those of the community. But there is room for a teaching which shall in a manner correlate all these, which shall reveal the sacredness of every duty and the profound significance of life. This is the teaching which especially deserves the name of religious, inasmuch as it awakens in the mind of the individual a consciousness of his relation to the universe as a whole, and an accompanying sense of universal law. Who, it may be asked, is sufficient for these things? Not every one assuredly who enters on the clerical profession. It is a vastly easier thing to denounce science as heterodox than to minister in any effective manner to the higher life of one's fellows. The latter, however, is the true function of the religious teacher, not the former; and it is a function the need for which was never greater than it is to-day. Science is advancing with giant strides, but discontent is on the increase. Why? Because the essential conditions of happiness are ignored; because rich and poor, however diverse their points of view in other respects, join in affirming that life consists in material abundance, that character is of little account, that money can do everything. In such a condition of things it is really surprising that religious teachers should find time to attack men of science for any views whatever which they may promulgate, the need being so pressing for a manifestation of those moral truths which no scientist would think of opposing, and which in point of fact no scientific doctrine can be said to touch. The fields are white to the harvest, but the really competent reapers are few. They would be more numerous perhaps if the needs of the time were better understood, and if men were not required to undergo an apprenticeship to outworn systems of thought before betaking themselves to the work of the ministry. We ask our religious friends to think of this. Science can not be arrested in its investigations, but these need not and do not stand in the least in the way of true religious work. Let the scientists, therefore, occupy their own field without molestation, and let the clergy—those who are fit for their high office—occupy their own field and labor to promote higher views of the worth and destiny of human life than those ultra-material ones which are so widespread to day, and which are nowhere more conspicuous than in the churches. Then we may have peace with progress.

A DANGEROUS CLASS.

In an article on The Unemployed, which appered in last month's Table, we ventured the opinion that one reason why the number of these was so great was that thousands of persons in the present day were receiving an education which they were not able afterward to put to any satisfactory use; and from an article by Mr. Goldwin Smith, which fell under our eye just as our own was finished, we were able to quote a passage strongly confirmatory of the position we had taken. Years ago Prince Bismarck had said the same thing in regard to Germany, and we remember how sharply a certain college president in this country resented the idea that college classes could by any possibility be too large, or engineers, architects, chemists, lawyers, doctors, etc., qualified or semi-qualified, be in too great proportion to the rest of the community. Of course, the financial prosperity of a college depends in a measure on the number of students it can attract, and we can understand why college authorities might not like the idea to get abroad that to send a boy to college is not always the wisest thing to do with him. Still, the truth that college education and semi-education can be overdone is one that, in our humble opinion, is destined to force itself, despite all that col-

lege presidents can say to the contrary, on public attention.

As regards Germany the opinion which, as we have said, Prince Bismarck expressed years ago is strongly confirmed by Mr. William H. Dawson's recent work on Germany. We take the following summary of his observations on this question from the London Saturday Review:

"He draws a very gloomy picture of the result of too many universities and too much higher education. We should like to think he exaggerated here, but we are forced to admit he does not. Twenty-two seats of learning are yearly 'turning out studied men in thousands,' and the unfortunate 'studied men' are lucky if, at the age of thirty-five, they are earning the wages of English bank clerks. The paternal state finds money for universities and looks to the qualifications for the professions and the civil service; but that paternal state can not provide its carefully examined would-be lawyers and doctors and civil servants and teachers with briefs and patients and posts and pupils; and, as a consequence, the educated unemployed increase mightily in numbers year by year. Still more formidable are the 'breakages'—the horde of superficially book-learned young fellows of the middle and lower middle ranks whom stupidly ambitious fathers have sent to universities (the state aiding) to fail in examinations when they ought to be selling groceries or hoeing potatoes. These undoubtedly form a truly 'dangerous class'; unfit for real intellectual effort, they have just sufficient smattering of letters, philosophy, economics, and science to make them the readiest tools of the agitator and the most permanent and effective nuisances to society, against which they have the very real grievance that they are unable to serve it in any useful way."

We have the case here very succinctly stated. These are the men who say that "the world owes them a living," the truth being that they have contracted a debt both for previous living and for education which they have little prospect of ever being able to wipe out. The sooner we recognize the fact that our modern systems of education are largely experimental, and that much of the way we have gone may have to be retraced, the better it will be for the permanent peace of society. At present we are using too much yeast of a not very wholesome kind, and the result is an excessive and dangerous amount of social fermentation.

LITERARY NOTICES.

The Story of the Sun. By Sir Robert S. Ball, F. R. S. Eleven Plates and Eighty-two Illustrations. 8vo. New York: D. Appleton & Co. Pp. 376. Price, $6.

This great story, draped in its simple yet eloquent diction, will perchance recall to the reader's mind some bygone evening when, by the shore of a sheltered and tranquil lake, he may have beheld reflected in its depths the crumbling glories of a nation's ancient structure, intermingling with the pinnacles of the modern edifice, devoted to the promotion of science in its latest reaches of infinite research. In such a scene, what food may not one find for reflection in a mental as well as the physical sense! The simile drawn may stand as reverting to certain antique theories of the sun, when contrasted with our nowaday ascertainable data.

Indeed, if this latest work of Sir Robert S. Ball were presented to the student stripped of all but the illustrations, it would, we feel assured, be pronounced a uniformly artistic and harmonious story without words. In the author's preparation of the work he gratefully acknowledges the assistance rendered him by such marked names in astronomical science as Prof. Pickering, of Harvard College Observatory; the famous French *savant* M. Flammarion; Prof. Holden, of Lick Observatory; Prof. Janssen, and many others. Even the reading of proofs was consigned to the charge of four unquestionable authorities. In all these aids, the essential purport of the volume, including such pronounced care, purity of style, logic-

al analysis, and the very latest research, must appeal to the reader through every line. In fact, wherever the spirit of inquiry inducing mathematical precision is found to supplant the imports of theory submitted on authority, this work will doubtless find a place; while, as registering unerringly the progressive steps taken to elucidate ascertainable knowledge regarding our great luminary, the scientific explorer can tread no safer ground than that prepared by the author.

In the opening chapters the principal features attaching to our solar system are submitted in detail, and it is shown that the sun in numerous senses becomes a center, apart from the geometrical position he occupies amid our own planetary system. For the fundamental elements of calculation needed to determine the true character of the sun we are indebted to the varying positions of the planets and the measurements they afford. Remotest antiquity, and the doctrines it taught concerning the solar system, are then treated at length, and contrasted with the advances made down to our own time. A problem of the utmost importance in all astronomical deductions—the actual distance of the sun—is treated of amply in the second chapter, where its leading characteristic is pointed out as involving the indirect method of computation. This distance becomes an abiding element in any conclusions to be drawn regarding the magnitude and nature of the solar spots, besides furnishing data for all prominences projected during a solar explosion, or as limiting the measure of the solar corona when expressed in miles.

The famous transits of Venus—which, by the way, afforded formerly the most trustworthy method of obtaining scales of the solar system—are commented upon at length in Chapter III, though, as the author points out, they now possess for astronomers but a historical interest. In connecting the sun's distance with the laws governing the velocity of light, a beautiful series of reasonings ensue, until we are introduced to the methods of measurement determining the sun's mass. Eclipses, and the story of the sun's spots, are magnificently illustrated and told with an ease and beauty only betimes found associated with a rare romance. Our seasons, past and present, fall next into line for their due share of philosophical comment and mathematical calculation; while "the sun as a star" assumes the unexpected garb of a diminishing speck of light in fathomless space, to be finally lost to the finite eye. In the closing chapter, the movements of the solar system, contemplated as a unit in space, are accounted by the author "one of the most daring exploits ever performed by astronomers," and brings this transcendent Story of the Sun to a close.

Factors that here and there throughout the volume break the intensity of interest excited in the reader are only momentarily dwelt upon as associated with special questions, which again, in their turn, rivet the attention. In a word, the scope of the writer's inquiry, like the boundlessness of his subject, becomes in the perusal a flood of light. In this we are lost by the hour, and our waking moments only seem to recall those breathless flights in childhood's wonderland, but, with this one and wide distinction, that our fancies only then revelled, where now, we feast on fact.

Speeches and Addresses of William McKinley. From his Election to Congress to the Present Time. New York: D. Appleton & Co. Pp. 664. With Portraits. Price, $2.

Governor McKinley is a politician of whom his most zealous opponents speak with general unqualified respect. They recognize his earnestness and sincerity, even though they may believe his views to be mistaken and mischievous. The present volume contains sixty-five of his speeches and addresses, selected from several hundred delivered in all parts of the country, by Mr. Joseph P. Smith, Librarian of the Ohio State Library, and revised by Mr. McKinley. Attention is invited by the editor to the care and ability with which Governor McKinley has discussed the tariff. All his more important speeches are collected and presented here, and probably embrace the most and strongest that can be said in favor of the doctrine of high protection. Besides, there are speeches on Gerrymandering, the Suffrage, and the Elections Bill, Labor, Pensions, the Public Schools, Civil-service Re-

form, the Currency, the Hawaiian Treaty, Memorial Addresses on Garfield, Logan, Grant, and Hayes; and several occasional addresses.

A Standard Dictionary of the English Language. Volume I, A–L. Edited by Isaac K. Funk, D. D., Editor in Chief; Francis A. March, LL. D., L. H. D., Consulting Editor; and Daniel S. Gregory, D. D., Managing Editor. New York: Funk & Wagnalls Company. Pp. 1060. Price (of two-volume edition, complete), russia, $15; morocco, $20.

There are more new departures in this work than in any other English dictionary that has appeared in the past half-century. In the arrangement of the matter under each word the greatest good of the greatest number has been deferred to rather than any historical or logical considerations. The order is, the respelling for pronunciation, the most common present meaning, less common uses, the original meaning if now obsolete or rare, and last the derivation. By this procedure the derivation and antiquated definitions, which are not wanted one time in six that even a comprehensive dictionary is consulted, are not placed where one must wade through them in order to get from the word to its present meaning. In the respelling for pronunciation the scientific alphabet devised by the American Philological Association is used, being supplemented by a few diacritic marks. The main features of this alphabet are those now adopted in all scientific notation of speech—namely, vowel sounds are represented as in Italian (or German) and consonants as in English. The dictionary, while recording all reputable usages in spelling, takes a positive stand in favor of simplification. The systematic spellings of chemical terms adopted by the American Association for the Advancement of Science are given preference over the old forms, being used in definitions. The moderately reformed spellings jointly approved by the Philological Society of England and the American Philological Association are inserted in the vocabulary, but the words that appear thus are defined under the common forms. The illustrations in the text are numerous, and besides these there are in Volume I full-page groups of cuts illustrating *architecture*, *coins* (ancient), *fowls*, and *horses*, also colored plates of *birds*, *decorations* (double page), *flags* (double page), and *gems*. The movements of many animals are illustrated from Eadweard Muybridge's photographs. Many names of classes have under them lists or tables of the varieties belonging to these classes. Thus under apple is a list of nearly three hundred varieties, the size, form, color, quality, use, season, and range of each being indicated briefly. Similar though less extensive lists are to be found under American (race), balsam, blue, calendar, constellation, dog, element, green, and many other words. The defining for this work has been largely done by specialists, and as a rule only a small class of words, with which he is especially familiar, has been submitted to each of these collaborators. Quotations used to illustrate definitions are exactly located. Lists of synonyms and antonyms are given for a large number of words. The vocabulary is very large; it will contain over fifty thousand more words than the six-volume Century Dictionary. The compounding of words has been treated systematically, special attention has been given to handicraft terms, and there are yet other notable features which we lack space to even enumerate. The Standard Dictionary is sure to make many friends and they will be firm friends.

Outlines of Pedagogics. By Prof. W. Rein. Translated by C. C. and Ida J. Van Liew. Syracuse, N. Y.: C. W. Bardeen. Pp. 199. $1.25.

The aim of this work is to furnish a brief introduction to the Herbartian pedagogics, on whose principles it is based. It presents the author's views as to the modern adaptation of those principles, a very important point; for while every thorough student of pedagogics must ultimately refer to the prime foundation—the works of Herbart himself—he can not afford to neglect the results that more than fifty years of development since Herbart's death have produced. The second edition of the author's work contained some essential additions and changes, on account of which certain parts of the first edition were removed to make room for the new. The omitted parts are restored in the translation, and all that both editions contained has been combined. The subject of pedagogics is divided by the au-

thor into Systematic and Historical Pedagogics; and Systematic into Practical and Theoretical Pedagogics. The systematic department is surveyed in the present volume.

Addresses Historical and Patriotic, Centennial and Quadrennial, delivered in the Several States of the Union, July 4, 1876–1883; including Addresses commemorative of the Four Hundredth Anniversary of the Discovery of America, 1892–1893. Edited by Frederick Saunders. New York: E. B. Treat. Pp. 1048.

In this portly volume are grouped the choicest of the great number of the eloquent and patriotic orations delivered in the several States of the Union during the series of centennial and multi-centennial anniversaries through which we have passed since 1876. They include many of various qualities of beauty and eloquence; many well-matured epitomes of the essential qualities of patriotic citizenship, many lessons pointing out what in our history is to be admired, and some things, perhaps, to be avoided. The facts and sentiments embodied in them cover the whole period of American history from the landing of Columbus down to the year 1893 They have been submitted to the critical supervision of their several authors. The publishers suggest that the reading of the book will tend to inspire a higher patriotism, and imbue the mind with true American principles. They ought to; but the result will depend upon the extent to which readers keep their minds clear from partisan blindness, which so often leads the best of us to the contradiction of what is right and best for the country.

The Pottery and Porcelain of the United States. An Historical Review of American Ceramic Art from the Earliest Times to the Present Day. By Edwin Atlee Barber. With Two Hundred and Thirty-three Illustrations. New York: G. P. Putnam's Sons. Pp. 446. Price, $5.

The author sets out with a contradiction of the impression, not sufficiently controverted even by our own writers, that the United States has no ceramic history. "On the contrary," he says, "it can be shown that the fictile art is almost as ancient in this country as in Great Britain, and has been developed in almost parallel, though necessarily narrower, lines." The work is based almost entirely upon thorough personal investigations, with patient and systematic research, study of the products of the potteries of the United States, and consultation with intelligent potters in the leading establishments. Care has been taken to omit "some of the time-honored fallacies which have been perpetrated by compilers," and to avoid the use of statements that could not be substantiated. Without attempting to give the history of every pottery that is or has been established in this country, the main purpose of the work is to furnish an account of such of the earlier potteries as for any reason possess some historical interest, and of those manufactories which, in later days, have produced works of originality or artistic merit. Beginning with a description of the processes of manufacture and a list and definition of American wares and bodies, the work treats, further, of aboriginal pottery, early brick and tile making, early potting in America (seventeenth century), potteries of the eighteenth century, operations during the first quarter of the present century, the American china manufactory, the pottery industry from 1825 to 1858, pottery work at East Liverpool and Cincinnati, Ohio, and Trenton, N. J., potteries established between 1859 and 1876; development of the ceramic art since the centennial, tobacco pipes, ornamental tiles, architectural terra cotta, American marks and monograms, and tiles for decorative effect. The author expresses himself highly gratified to be able to call the attention of lovers of art to the remarkable progress which has been made in ceramic manufacture among us within the past fifteen years; and adds that if his efforts shall result, in any measure, in the breaking down of that "unreasonable prejudice which has heretofore existed against all American productions," he shall feel that he has been abundantly rewarded. In his chapter of Concluding Remarks he observes that "thus far our potters have been, in a great measure, imitative rather than inventive, and the result is that we have largely reproduced, though in a most creditable manner, patterns and designs, bodies, glazes, and decorations of foreign factories. With some few exceptions, our commercial manufacturers have been content to copy and imitate the products of foreign establishments, and have, in

consequence, unconsciously assisted in perpetuating certain offenses against good taste." The feeling that prefers articles and designs at first hands can hardly be called an unreasonable prejudice. Whatever it is, originality, with equality of merit, will go far to counteract it. It will be worth trying as a substitute for a McKinley tariff. Mr. Barber believes that "America, within the next few decades, is destined to lead the world in her ceramic manufactures." The work is sumptuously presented by the publishers in the best style of bookmaking.

Geological Survey of New Jersey. Annual Report of the State Geologist for the Year 1892. By John C. Smock, State Geologist. Trenton: The John L. Murphy Publishing Company. Pp. 367, with Maps.

In this report are incorporated, as leading heads or parts thereof, the reports of progress made in the various lines of investigation of the several departments of the works of the survey, as follows: Surface Geology; Cretaceous and Tertiary Formations (preliminary report); Water-supply and Water-power; Artesian Wells in Southern New Jersey; and the Sea Dikes of the Netherlands and the Reclamation of Lowlands and Tidemarsh Lands. These reports are to some extent separate and independent of one another, although all have for their object the elucidation of the facts of the geological structure and physical geology of the State, and as an ultimate end the information of the people in order to the highest development of the natural resources of the State. The administrative report, introductory to the reports of the several divisions, besides remarks on the topics already mentioned, has discussions of drainage; natural parks and forest reservations; the work of the United States Geological Survey in New Jersey; and the geological survey exhibit for the Columbian Exposition.

The maps represent the whole State, with reference to its water-supply sheds, and the special geology of parts of Monmouth and Middlesex Counties. The treatment of all the subjects is full, satisfactory, and adapted to practical ends; and the report is, as a whole, one of the most interesting the survey has issued.

Primer of Philosophy. By Dr. Paul Carus. Chicago: The Open-Court Publishing Company. Pp. 232. Price, $1.

The author seeks to present his subject in the plainest and simplest manner he can. His point of view is not susceptible, he says, of being classified among any of the various schools of recent current thought, but represents rather a critical reconciliation of rival philosophers of the type of Kantian apriorism and John Stuart Mill's empiricism. The names of positivism and monism are taken as expressing the philosophical principles which dominate modern thought. Either is complementary to the other. Positivism represents the principle that all knowledge—scientific, philosophical, and religious—is a description of facts; monism is a unitary conception of the world, presenting it as an inseparable and indivisible entirety. It stands upon the principle that all the different truths are but so many different aspects of one and the same truth. Monistic positivism or positive monism "is, and always has been, the principle of all sound science. The positive and monistic maxims of philosophy were perhaps not sufficiently appreciated in former ages, but they are growing to be clearly understood now, and will in time lead to the abandonment of all transcendental, metaphysical, supernatural, and agnostic speculations. Positive monism will change philosophy into a systematization of positive knowledge."

Number Work in Nature Study. By Wilbur S. Jackman. Chicago: W. S. Jackman. Pp. 198. Price, 60 cents.

In secondary schools the study of mathematics demands a large share of the pupil's attention, and little effort has been made thus far to rescue the hours passed in solving arithmetical puzzles or algebraic enigmas. Even in grammar schools it is excellence in arithmetic rather than in the construction of language which forms the standard of scholarship. The author of this manual believes that much of the time spent in mastering arithmetical processes could be also utilized in Nature study. If the pupil obtains material, makes his own observations and comparisons, the mechanism of the subject will be incidental, and instead of meaningless results or unintelligible values

he will gain thereby an idea of some general law. To remedy the frequent inexactness of beginners, it is advised that continual use should be made of balances, weights, rulers, and protractors, and definite quantities always required. The mathematics involved are the four fundamental rules of arithmetic, fractions, ratio, and percentage, and the problems for study are sufficiently varied, being taken from seven departments of science.

The method is good, but several of the subjects appear beyond the grasp of a pupil in percentage. While interest may be aroused in the colors of insects, the constituents of fruits, or the process of evaporation, it is hardly possible that the ratio of the area lying south of the mean annual isotherm of 50° Fahr. to that lying south of the mean annual isotherm of 40° Fahr., or calculations of rainfall and drainage, should be more comprehensible or attractive to the average boy than questions in taxation and insurance.

Plato and Platonism. By Walter Pater. London and New York: Macmillan & Co. Pp. 256. Price, $1.75.

However materialistic the mood of the reader may be, these lectures are apt to take him unawares and hold him for a time completely under their spell. He wanders amid the groves of the Academy and listens to Socratic dialogue until he becomes somewhat hypnotized and is prepared to meet the Just and the Beautiful face to face. Not that Mr. Pater inculcates the possibility of any such actual vision. He pronounces the theory of the many and the one difficult doctrine and acknowledges that, with all allowance for poetical expression, the universals to which Plato would introduce us are very much like living beings.

In order to form a just or historic estimate of Platonism, the conditions of its genesis and growth must be examined. Mr. Pater projects for us in vivid outline the Greek intellectual life preceding Socrates. The philosophy of Plato was a protest against the doctrine of Heraclitus. His dogma of universal change, *πάντα ῥεῖ*, is not unlike the modern idea of development and evolution, but to Plato it was in the highest degree repugnant. Recognizing the tendency to vary, he considered it an evil to be corrected, and sought in the nature of man, in culture, in society, for an unalterable *κόσμος*. In the Republic he shows how this order may be established in a community.

Personally, Plato is depicted not as a rigid philosopher wrapped in speculations, but as a keenly impressionable nature with every sense sharpened to the external world. This gives "an impassioned glow to his conceptions," and endows his writing with the fineness of Thackeray.

According to modern views, two radically divergent tendencies are discoverable in Platonism. First, the theory of ideas, that the highest knowledge is intuitive and absolute. Secondly, the dialectic method, the endless question and answer, the weighing of every minute grain of evidence. Mr. Pater considers that we owe not only this method, "a habit of tentative thinking and suspended judgment," to Plato, but that it is straight from his lips that the language came in which the mind has ever since been discoursing with itself.

In conclusion, if we doubt Plato's immutable ideas, we may still seek for the ideals he pictures. If we reject his communistic theories, we can accept his classification of the orders of men, the intellectual, the executive and the productive. We may even strive to realize his dictum that those who come to office should not be lovers of it! As for his contention with the Sophists, that is a question of to-day. Which is essential, matter or form? Should the artist and writer know and feel the truth himself, or only know what others think about it? If we believe the former, we may go to the Phædrus for inspiration.

Governments and Politicians, Ancient and Modern. By Charles Marcotte. Chicago: Charles Marcotte, 175 Monroe Street. Pp. 478. Price, $2.

The merits of this work are anything but inconsiderable when viewed from the standpoint of a measurable reforming medium. More. The author's sincerity and thoroughness of purpose manifestly inheres between the lines on every page. We leave it, however, to the judgment of others to say whether the "Constitution" of this country —as alleged—is responsible for the existence of "professional" and "unscrupulous"

politicians as well as the faulty results of our "primary elections." An antagonist worthy of the author's steel might be the Hon. W. E. Gladstone, who declares the "Constitution" in question to be the greatest "fiat" that ever issued from the hands of men. We ourselves have somehow the impression that unscrupulous politicians and packed primaries exist in spite of the Constitution. Nevertheless, the volume before us tends to modify the weight that Americans customarily attach to their non-anyletical method of dealing with national shortcomings and political abuses. Further, the author places us *en rapport* with the monarchical governments of Europe, both ancient and modern, and strenuously argues in favor of similar policies—or at least one such institution—being adopted in the United States. Notwithstanding the trenchant analysis applied, as long ago as and by Lord Bacon, to the faultiness—under specified conditions—of the syllogistic argument, and its invalidity as demonstrated by the late John Stuart Mill; still, Mr. Marcotte very quietly settles the "divine right of monarchy" as follows: "The form of government which best administers justice is of divine right; monarchy is that which best administers justice; therefore, monarchy is of divine right." Evidently our author cares very little or nothing for previous questions.

But the foregoing sample is the very worst feature of a work the contents of which introduce us to such excellent matter as the story of Democracy, the Greek Republics, Media and Persia, the Athenian Commonwealth, the Roman Empire, the Great American Republic, the Origin of the American People, etc. In a second edition of this work the author's genuine good nature will doubtless incline him to deprecate pessimism and anticipate an epoch on this continent when impartiality will have become a necessity and human justice as natural as the law of gravitation.

Secularism: Its Progress and Morals. By John M. Bonham. New York: G. P. Putnam's Sons. Pp. 396. Price, $1.75.

A work that forces reflection of an ethical nature will inevitably fill an exalted niche within the radius of scientific activity. Such a volume lies before us and invites the reader's thoughtful consideration for many good reasons. The philosophy underlying the inferences deduced in Secularism will—as far as one can judge—have a twofold effect. Such as may deem it a duty to oppose the author will indubitably have to reconsider their own position, and those who agree with him, will doubtless discover new data wherewith to augment their polemical outfit.

The scope of the question taken up by Mr. Bonham is far from limited by even the copiousness of his book, though the comprehensiveness of the author's design is apparent throughout. The main initial purport of the argument, as a whole, is to examine minutely the relative force of influences bearing upon beliefs theological, in the first place through industrial results, and in the second by such surroundings as are traceable to the intellectual field of view. The next point of import rendered lucid by the author's method of reasoning is the fact that the masses, with but few exceptions, are disinclined to philosophical abstractions, and that those influences which go farthest to build up their ethical natures are discoverable in their occupations and the deductions supplied from inductions gathered through the physical phenomena affecting their daily lives. This would be putting the matter with unwarrantable brevity were we unable or disinclined to further note the exhaustiveness of this engaging book. Besides the superiority of relative truth over the presumptions of supermental dicta being succinctly treated, the history of the decline of theologic anathema against ascertained knowledge finds a place. The true value of authority *per se* is justly weighed, and the evolution and dissolution of things once sacred are so touched as to evidence a decided mastery over historical detail. The chapters on Ethics are lengthy and full to diffuseness in their estimate of the comparative values of the scientific and theologic theories affecting conduct, together with the impersonal entities that frequently control ethics. There is nothing perfunctory—no uncertainty of tone in the treatment of secular as contrasted with ecclesiastical morality. Idealism, realism, intuition, justice, the laws of Nature, and the assumptions that have signally failed to explain ultimate causes, all receive their full quota of consideration.

As if to crown Mr. Bonham's effort we find in his work an entire absence of sensational effect. No temporary expedients of argument are resorted to, and altogether its tone is genuinely altruistic.

In the series of *Correlation Papers* on the several formations of North America, now being issued by the Geological Survey, the third, fourth, fifth, and sixth papers have been published as Bulletins 82 to 85. The third paper has the special title *Cretaceous*, being an examination of the formation of this name, by *Charles A. White*. The chief cretaceous area of the United States is an irregular belt extending from Texas northward through the region of the great plains and continuing into western Canada. There are also small areas in the middle and southern Atlantic coast States. The next paper is on the *Eocene*, by *William B. Clark*. The author finds that the marine faunas of the Atlantic and Gulf coasts permit a separation of the Eocene as a whole from formations belonging to earlier and later periods with a high degree of confidence, but that with present evidence the lines of separation are not sharply drawn among the marine and fresh-water formations of the Pacific coast and the interior region. The *Neocene* is discussed by *William H. Dall* and *Gilbert D. Harris*. Besides assembling the published material concerning its subject, the memoir makes original contributions based on investigations by Mr. Dall. In respect to Florida these contributions are so important that it has seemed best to expand the chapter on that State so as to include practically all that is known of its geologic history. The sixth in this series is by *Israel C. Russell*, on *The Newark System*. This system is confined to a chain of small areas extending from North Carolina to Massachusetts, with a continuation in Nova Scotia. Each of these monographs contains a bibliography and is illustrated, the last one being especially well embellished with colored maps, and its bibliography occupying over two hundred pages.

Three recent Bulletins of the United States Geological Survey embody physical researches by Dr. *Carl Barus*. No. 92 is on *The Compressibility of Liquids*, and embodies results which it is hoped will throw light upon the behavior of the liquid mass underlying the crust of the earth, and the phenomena of upheaval and subsidence of the crust. No. 94 deals with *The Mechanism of Solid Viscosity*, steel and glass being the substances taken for experiment. A paper on *The Volume Thermodynamics of Liquids* appears as No. 96. The results that it contains are confined to volume, pressure, and temperature; questions involving entropy and energy are under investigation. The researches upon which Dr. Barus is engaged were suggested by Mr. Clarence King, who has pointed out the importance of a deeper insight into the volume changes of liquids and solids.

Mr. *Bashford Dean*, of Columbia College, has supplemented his report on oyster culture in France with one describing the methods used in other countries of western Europe, under the title *Report on the European Methods of Oyster Culture*. The topics treated comprise the management of natural oyster grounds, production of seed, rearing young oysters, and the governmental regulation of oyster grounds. The monograph is illustrated with fourteen plates. It forms part of the Bulletin of the United States Fish Commission for 1891.

In Volume XII of the *Transactions of the New York Academy of Sciences* are papers on Dionæa, by Bashford Dean; The North American Species of the Genus Lespedeza, by N. L. Britton; Fact and Fallacy in the Boomerang Problem, by C. H. Emerson; Phosphate Nodules from New Brunswick, by W. D. Matthew; Progress of Chemistry as depicted in Apparatus and Laboratories, by H. C. Bolton; The Sunapee Saibling, by J. D. Quackenbos; Memoir of Prof. J. S. Newberry, by H. L. Fairchild; Petrography of the Gneisses of the Town of Gouverneur, N. Y., by C. H. Smyth, Jr., and the Cretaceous Formation on Long Island and Eastward, by Arthur Hollick. There is a frontispiece portrait of Prof. Newberry.

An extended *Report on the Brown Coal and Lignite of Texas*, prepared by the State geologist, *Edwin T. Dumble*, has been issued. The origin, character, and modes of using brown coal in general are stated in considerable detail, after which the geology, occurrence, and composition of the deposits found in Texas are set forth. Comparisons of the Texas product with European and with bituminous coal follow, and a chapter

on the utilizing of the former completes the volume. The text is illustrated with twenty-five plates and thirteen figures, showing engine grates and grate-bars, briquette presses, the arrangement of certain mines, sections of coal deposits, etc.

A fourth edition of *Standard Tables for Electric Wiremen*, by the late *Charles M. Davis*, revised and edited by *W. D. Weaver*, has been issued (W. J. Johnston Co., New York, $1). The new edition contains the latest revisions of the Insurance Rules of the Underwriters' International Electric Association, also an important section on the calculation of alternating current wiring. A number of the most important tables were prepared expressly for this work, and, being copyrighted, can not be found elsewhere. Among these are the tables of alternating current wiring coefficients, those on limiting currents for exterior wiring and on the candle power of arc lamps, and the table enabling the ones for the three standard lamp voltages to be used for any voltage or drop, as well as several others, including a complete set of wiring tables calculated on a uniform basis of 55-watt lamps.

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POPULAR MISCELLANY.

Reptilian and Amphibian Motions.—M. Marey has extended his time-photographic studies of locomotion to mammals, birds, reptiles, fishes, and articulates. The processes are rather difficult, because they have to be applied to a great variety of movements, and of methods and habits of carrying them on; but it is nearly always possible to assure satisfactory representations by adapting the methods of working to the conditions. The chief difficulty is in getting the animal experimented upon to go at its ordinary gait. This is much more easily accomplished with domesticated animals than with wild ones. By comparing the types which he has got represented, M. Marey discovered some very interesting analogies. Thus, in locomotion on land and on water, he was able to follow the gradual transition between simple "reptation" and the most complicated kinds of locomotion. An eel and a viper, put in water, advance in the same manner; a wave with lateral inflections runs continuously from the head to the tail of the animal, and the velocity of the retrograde movement of the wave is much greater than the speed of translation of the animal. If the animals are set upon the ground, the mode of reptation will be modified in both in the same way. The amplitude of the undulatory movement from one side to the other will be greater, and will increase as the surface on which the animal creeps is smoother. A vestige, more or less pronounced, of the undulatory reptilian movement remains with fish that have fins and reptiles endowed with legs. In the sea-dog, for instance, the retrograde wave running along the whole body is very pronounced. It is considerably reduced in the salmonides, and does not appear except at the tail in fishes the bodies of which are more stubby. This retrograde wave is plainly manifest in the gecko, but less so in some other lizards. The analysis of the varieties of locomotion of the batrachians in the different stages of their evolution is very interesting. The tadpole, for example, exhibits in its earliest stage progression by the undulation of the caudal fin; a mixed type of locomotion comes in with the paws; the tail continues to wriggle, and the hinder limbs make the swimming motions appropriate to them; and the latter movements exist alone for some time after the tail has disappeared. These motions, which so much resemble those of man's swimming, present the peculiarity of the fore legs having no part in them, and of the hind legs, after having been separated so widely as to form a right angle with the axis of the body, approaching one another till they become parallel, then bending and spreading out again to begin a new spring. The motions of lizards' legs are so swift as to escape direct observation, but the successive movements of the fore and hind limbs can be followed in photographs taken forty or fifty times a second. The normal gait of the lizard and the gecko is the trot—that is, their limbs move diagonally. The great amplitude of the motions, combined with the undulation of the axis of the body, causes the limbs on the same side to come very near one another, and then separate widely in the following instant. The lizard projects its hind foot nearly into its armpit on the side on which the body becomes concave; an instant afterward that side becomes convex, the fore leg is carried far forward, and, the body forming a convex arc on that

side, the two limbs are widely separated. Interesting observations have also been made of the motions of insects, arachnids, etc.

Modern Survivals of Primitive Superstitions.—The recently published book of S. Baring-Gould on Strange Survivals furnishes curious suggestions concerning the origin and primary meaning of many customs and practices that have come down to us from remote ages, and which we observe or remark upon without a suspicion of their significance. The superstition has gone out of vogue in civilized lands that the sacrifice of a human being in its foundations is necessary to the stability of any important building. But King Theebaw, of Burmah, in our own days, obeyed it; and the feeling remains among the superstitious in Europe that some unseen power must be propitiated, or it will some time and somehow exact its dues; and numerons legends prevail with reference to grand structures of how the mysterious powers were propitiated in the beginning, or exacted an equivalent for the neglected sacrifice. Only fifty years ago the people of Halle are said to have tried to persuade the builder of a bridge to immure a child in the foundations in order to insure the stability of the piers. The designs of gable ends, carved ridge-tiles, representations of animals, such as horses and horsemen, and the stone balls with which houses are adorned, all have meanings. The completion of a building was signalized by a sacrifice originally, just as the laying of the foundations was. Horses were held to be sacred by the Northern races, and formed, next to a man, the worthiest sacrifice; and if a horse's skull was not put on the point of a gable, a horse's head was carved. At a chieftain's death, his horse was buried with him; and to-day the charger of an officer follows his coffin to the grave. Poles, surmounted by branches of leaves and flowers, protect the farmhouses of the Black Forest from lightning, and represent the ancient oblation of a bunch of grain to Odin's horse; and gables often have carvings connected with this oblation to Odin. At Yuletide oats are thrown out for Santa Claus's horse (the colt of Odin having been transferred to Santa Claus), and a person convalescent after a dangerous illness is said to have "given a feed to Death's horse." The sheaf of corn that is fastened to the gable in Norway and Denmark—now an offering to the birds—was originally a feed for Odin's horse. Formerly, the last bundle of oats in a field was cast into the air by the reapers, for Odin at Yule to feed his horse; and a similar custom prevailed in Devonshire, in Mr. Baring-Gould's recollection. The mediæval habit of affixing the heads of criminals to spikes on battlements was the survival of the offering of skulls to Woden, and the stone balls on the gables of manor houses and on lodge gates are the survival of the right of life and death possessed by the lords of the manor.

"State Socialism" in New Zealand.—At a recent meeting of the Royal Colonial Institute of Great Britain the Earl of Onslow described some experiments in what was called state socialism that had been undertaken in New Zealand. The Government had expended large sums in providing water for mining purposes for working miners, and had given the men the task of repairing the water works, remunerating them, not in money, but in orders for water for the purpose of getting gold. It had worked a system of settling men upon land, with advances of money for house-building and cultivation. In a visit to two of these settlements—one formed by voluntary association, and the other from the unemployed—the speaker had found the voluntary association prosperous, while the unemployed were calling upon the Government to take them out of "the hole" they had been brought into; and he formed the opinion that, while the Government was not in any case without ample security for its advances, yet only careful selection of the land and of the men would secure success. The colony had acquired by purchase, at the owner's valuation, the largest estate in the country, and opened it for settlement; and he believed that, so long as it did not unduly saddle the colony with debt, this experiment in the resumption of the national estate would be likely to prove satisfactory to the Government. The labor department in New Zealand had been more successful than the one abolished last May in Victoria, because numerous country branches had been created instead of calling all the workmen to the central office in the capital. In the system

of co-operation on Government work, the men form themselves into gangs, the strong with the strong and the weak with the weak, so that the weak, although they could not execute work rapidly, were yet not altogether excluded from employment. Two interesting results of the experiment of introducing labor leaders into the Government were noted: when intrusted with power, they became imbued with a sense of responsibility, and could successfully resist the establishment of state charity in the guise of work or unprofitable undertakings, and members of a revising chamber, drawn from whatever party, would resist measures which they believed not to be the deliberate will of the people.

Succession of Arctic Seasons.—In his presidential address before the Geographical Section of the British Association, Mr. Henry Seebohm gave a graphic description, largely drawn from personal experience, of the succession of the seasons in the high arctic latitudes. He said that the stealthy approach of winter on the confines of the polar basin is in strong contrast to the catastrophe which accompanies the sudden onrush of summer. One by one the flowers fade and go to seed, if they have been fortunate enough to attract by their brilliancy a bee or other suitable pollen-bearing visitor. The birds gradually collect into flocks, and prepare to wing their way to southern climes. The date upon which winter resumes its sway varies greatly in different localities, and probably the margin between an early and a late winter is considerable. The arrival of summer happens so late that the inexperienced traveler may be excused for sometimes doubting whether it really is coming at all. When continuous night has become continuous day without any perceptible approach to spring, an Alpine traveler naturally asks whether he has not reached the limit of perpetual snow. It is true that here and there a few bare patches are to be found on the steepest slopes, especially if they have a southern exposure. It is also true that small flocks of little birds may be observed flitting from one of these bare places to another; but their appearance does not give the same confidence in the arrival of summer to the arctic naturalist as the arrival of the swallow or the cuckoo does to his brethren in the subarctic and subtropic climates. The birds seen are only gypsy migrants that are perpetually flitting to and fro on the confines of the frost, continually being driven south by snowstorms, but ever ready to take advantage of the slightest thaw to press northward again to their favorite arctic home. The gradual rise in the level of the river inspires no more confidence in the final melting away of the snow and the disruption of the ice which supports it. In Siberia the rivers are so enormous that a rise of five or six feet is scarcely perceptible. During the summer which the author spent in the valley of the Yenisei there were six feet of snow on the ground. To all intents and purposes it was midwinter, illuminated for the nonce with what amounted to continuous daylight. During May there were a few signs of the possibility of some mitigation of the rigors of winter, but these were followed by frost. At last, when the final victory of summer looked most hopeless, a change took place; the wind turned to the south, the sun retired behind the clouds, mists obscured the landscape, and the snow melted "like butter upon hot toast. . . . The effect on the great river was magical. Its thick armor of ice cracked with a loud noise like the rattling of thunder, every twenty-four hours it was lifted up a fathom above its former level, broken up, first into ice-floes and then into pack-ice, and marched down stream at least a hundred miles. Even at this great speed it was more than a fortnight before the last straggling ice-blocks passed our post of observation on the Arctic Circle; but during that time the river had risen seventy feet above its winter level, although it was three miles wide, and we were in the middle of a blazing hot summer, picking flowers of a hundred different kinds, and feasting upon wild ducks' eggs of various species. Birds abounded to an incredible extent."

Analysis of Volcanic Ashes.—An analysis has been made by M. A. F. Noguès of the ashes and volcanic sands thrown up by the volcano Calbuco, in Chili, during an eruption which began in February, 1893, and had not ceased in December. The fine dust products were projected to places as far off as Moutt, Valdivia, and La Union, at distances varying from twenty-five to one hundred and twelve

miles. They contained no vitreous grains, but simply the minerals that constitute the andesites of which the mass of the mountain is composed, and in the same state as in them. The andesite of the prehistoric eruptions of the region when reduced to powder and traversed by the vapor of water gave the same products as the ashes cast out in 1893 by the volcano. These ashes, therefore, appear to have been derived from the trituration and pulverization of the old lavas of the region without their having been remelted. The author remarks that the eruption of Calbuco has given out such considerable quantities of watery vapor that the usual atmospheric conditions have been materially modified by it. Rains are abnormally abundant even in central and northern Chili, with snows on the mountain chains and the sky covered with clouds—conditions very different from those which normally prevail in the country.

Children's Letters.—The characteristics of children's letters are pertinently described in the London Spectator, which says that the writers "come straight to the point, and get down with it, with a unanimous contempt for self-advertisement, which shows that the dislike to be 'drawn' on matters nearly affecting themselves, which is common to the oldest and wisest of mankind, is fully shown by their youngers and betters. The child is, in this, the father of the wise man. Not that they refuse information. The bare facts are always at the service of the public. They fall into 'common form,' and in a score of letters written by very young children it is difficult to find one in which the decorous reticence as to self is exceeded. Their age, very accurately stated; the number of their brothers and sisters, among whom the last baby naturally takes a leading place; and, possibly, a description of their home, limited, as far as possible, to the information given in their postal address, is evidently considered to be sufficient data from which to form an idea of themselves and their surroundings. Then, in nearly every case, follows a list of the household pets. Judged by the evidence of children, the dog is in every case the most important personage, next to the baby, in the estimation of the nursery. His size, accomplishments, and benevolence, his good or bad temper, and in every case his name, are given with a conscientious and personal interest which is accorded to no other animal. Apparently, there is no limit to the number of pets which the fathers and mothers of our race, whether English, American, or Anglo-Indian, set to the fancies of their children. . . . Looking through a pile of letters from children, mostly girls of all ages from four to thirteen, the writer finds nearly three quarters devoted to careful accounts of dogs, tame mice, a donkey, 'Joey,' a 'ginipig,' 'rabits,' chickens, goats, and innumerable pigeons. There is hardly a word about themselves or their feelings in the whole collection, though the health, wants, and probable sentiments of the animals are treated at great length and with every diversity of spelling. Lists of 'what the pigeons have got'—such as 'the fantail,' two babies and one egg; the 'Jocobin, two eggs,' etc.—are followed by other lists of 'ones that have got nobody.' Chickens are counted before they are hatched and after; and terrible descriptions of the results of a cock-fight, which has made one of the combatants 'all bloddy,' are given at great length, with accounts of the illness, treatment, and burial of other creatures. Events, such as games, parties, or expeditions, are, as a rule, only mentioned, without comment."

Photography of Colors.—The process of photography of colors, discovered a few years ago by M. Lippmann, has been considerably improved, and has now been brought to such a degree of perfection that with it the composite colors of natural objects, such as flags, flowers, and fruits, a multicolored parrot, and a window with four colors, are photographically reproduced. In the hands of M. M. Lumière it has been applied successfully to chromolithographs, natural landscapes, and portraits. The time of exposure required has been reduced from thirty minutes a few months ago to from three to five minutes. While so much has been accomplished in this art, many requirements remain to be fulfilled: the time of exposure to be further reduced; accurate isochromatic plates to be obtained, and a way found of taking proofs on paper. The colored proofs have the property of the old-fashioned daguerreotypes, of not being

clearly visible except when viewed at the right angle. This property, however, has the great advantage that it makes retouching of the picture impossible. To remedy the inconvenience arising from it, M. Lippmann has devised an apparatus for viewing the pictures by the aid of which the proper conditions of the angle can always be obtained.

Toads and Cancers.—Toads were used during the last century as local applications for the cure of cancerous breasts. An account of a cure said to have been wrought by this means is given in Martin's Natural History, published in 1785, from a letter from a physician to the Bishop of Carlisle. The doctor had attended the operation for eighteen or twenty days, and was surprised at the result. The toad was put into a linen bag, all but the head, and that was held to the part. It was supposed to suck the poison till it swelled up and died. Then other toads were put on, and so, till the sore was cured. Sometimes they disgorged, recovered, and became lively again. Other authorities, the writer said, held that the toads did not suck the poison, although they admitted that the swelling and falling off dead was a general consequence of the application. Dr. Leonard G. Guthrie shows, in the Lancet, that a toad can not suck, but when injured or alarmed blows itself up to about twice its ordinary size, and when held and constrained for any length of time in a hot hand, sweats profusely and would probably soon die. The effect of the secretion when held on the hand is to cause dryness, numbness, and a tingling; which it probably did to the cancerous breast, giving a sort of relief to the pain.

A "Sanitary" Building.—Dr. W. Van der Heyden, of Yokohama, Japan, has designed a sanitary building, in which he seeks in winter to imprison the heat-rays of the sun, and in summer to admit the light while excluding the excess of heat; and at the same time to afford perfect ventilation and security against disease germs. The walls of the houses are made of air-tight boxes with sides formed of panes of glass, built upon one another, hermetically jointed with felt, and filled with a solution of alum; the roof is covered with cement. "A house built in such a way is an entirely closed hollow space, like a box itself, without windows or doors—no openings, and no fissures. It is practically impermeable to air, moisture, heat, cold, dust, microbes, and insects." At convenient intervals in the walls of rough plate glass are plates of polished glass, to be used as windows for looking out. "Doors are not wanted, because the entrance can be made through the floor by means of a lift or staircase from an underground room which receives no direct light from the sun. The walls of the underground room are made of ordinary bricks, plastered inside, and protected outside with a thick layer of clay to keep out moisture; it will be better to have these walls constructed with iron plates, as quick conduction of heat is the requisite here. The light for this room comes through glass boxes let in the four corners of its ceiling which forms the floor of the upper room. . . . There is a nice mild diffused light in the lower room which fully enables one to do any laboratory work, and is sufficient to read by." The walls are protected against freezing in winter by inclosing the whole building in a covering of window glass. In the summer the window-glass frames are put within the house, and furnish air cushions, still further preventing the accession of outside heat. Special arrangements are made for the renewal of air, heated in winter and sterilized at all times; and as the house is proof against the entrance of air from any other source, all microbes, disease germs, infections, and insects are efficiently kept out. The author has tried his house, and thinks well of it.

Temperature of the Interior of Trees.—The experiments of M. Prinz on the variations of temperature in the interior of trees seem to show that the sap contains large quantities of gas, which escapes with a sound often quite marked, and which can sometimes be heard two steps away. The mean annual temperature of the interior of a tree corresponds with that of the external air; but the monthly mean sometimes varies by two or three degrees. It usually requires about a day for a fluctuation of temperature to be transmitted to the heart of a tree. While the difference between the interior temperature of a tree and that of the air is

usually only a few degrees, it is sometimes as much as ten degrees; when the temperature of the air falls below the freezing point and continues to fall, the internal temperature of a tree descends to a point near that where water of vegetation freezes and continues there stationary. Water of vegetation freezes a few tenths of a degree below the freezing point of water. The absolute maximum in the interior temperature of a tree trunk may be produced a considerable time before the maximum of the surrounding air, in consequence of the direct action of the spring sun and air on the leafless trees. During the high summer heats the internal temperature of trees is nearly steady at about 15° C., with a variation of two degrees or more, even under exceptional conditions of variation in the temperature of the air. A large tree is usually a little warmer than the air in the cold months, and a little cooler than the air in the warm months.

Anatomy and Physiology for Young Men.—Writing to the projectors of the Quarter-Century testimonial book to Prof. Burt G. Wilder, Dr. Andrew D. White refers to one point on which Prof. Wilder in the early days was able to render a special service outside of his chosen field. "While the university was in its earliest beginnings, a sort of nebulous state, I was impressed by a remark by Herbert Spencer, in his book on Evolution, as regards the relative values of different kinds of knowledge. He named, among the things to be taught to young men, human anatomy and physiology; and his arguments seem to me now to be absolutely conclusive. For apart from the practical part of these studies, they seem to form a most stimulating beginning to study in natural history generally, not perhaps the logical beginning but the best practical beginning, as is shown by the fact that in all ages the great majority of students of note in natural science have been physicians. Under the influence of this impression I asked Prof. Wilder to give a course of lectures every year to the freshman class on anatomy and physiology. Various arguments might have been used against this; it would have been said that, later in their course, students would have been better prepared to appreciate the fine points of such lectures, and the example of all the older institutions might have been pointed to in which such lectures, when given at all, were generally given as a hurried course in the senior year. But the idea of making an impression in favor of studies in natural science, and especially in human anatomy and physiology, just when young men were most awake to receive them, carried the day with me, and hence my request to Dr. Wilder. He acceded to it at once, and for several years, in fact, until the pressure of other duties drew him from this, he continued these lectures, and it turned out that I had builded better than I knew; not only did the lectures produce admirable practical results, not only did they stimulate in many young men and women a love for natural science and give them an idea of the best methods in its pursuit, but they made a most happy *literary* impression upon the students generally; the professor's wonderful powers of clear presentation in extemporaneous lectures proved to be a wonderful factor in literary as well as scientific culture. There was another theory of mine proved to be true by the professor; for I had often felt that mere talks about literature, mere writing of essays, the mere study of books of rhetoric, were as nothing in their influence on the plastic minds of students compared with lectures thoroughly good in matter and manner given in their hearing day after day. Naturally I have always felt exceedingly grateful to Prof. Wilder for proving that theory true and at the same time rendering a great service to his students and to the university."

Preparation of Collections.—In his report of the Department of Botany and Forestry in the State Agricultural College of Michigan, Prof. W. J. Beale gives a list of the more common mistakes which young collectors are apt to make in preparing their collections, the perusal of which may give hints of the manner in which the work should be done. They are: The specimen is a mere "snip" of a thing, one little top, destitute of lower leaves, of roots, and root stalks, instead of enough to fill completely a whole sheet. In many instances the plant is pulled into small pieces, and runners, sterile shoots, old leaves, etc., are thrown away; specimens lack fruit, which is often of more importance

than are the flowers; if tender and young, they are pressed too hard, or later in the season are not pressed sufficiently to make the leaves dry flat. Too many use newspapers for the light sheets on the driers. The printed letters were made with oil, and such spots can take up little moisture. Plants are put in driers which are not thoroughly dried by the heat of the stove or the direct rays of the sun. The old-fashioned press made of tight boards is a clumsy device, but still in use. Plants are not changed two or three times a day on the start, and all this time kept in a warm place—hence the color is not good; they are too long for mounting, and must be broken or cut off or cut in two to fit the sheet of standard size. For the proper methods, novices are referred to certain articles in botanical journals, to a chapter on the subject in Gray's large text-book, "or, better still, to hang about and worry some good collector and see how he does it."

Bathing after Exercise.—The Lancet observes that "the popular notion of the injurious effect of a cold bath taken by one who is overheated from exercise must possess—as all such ideas have—some basis in experience; and yet it is falsified by the experiences of athletes from the days of the Greeks and Romans even until now, who find in this procedure a refreshing and stimulating tonic after the exertion they have recently undergone. And, physiologically speaking, a cold plunge or douche taken immediately after the physical effort, when the skin is acting freely and there is a sense of heat throughout the body, is as rational as in the experience of the athlete it is beneficial. It is paralleled by the tonic effect produced by the cold plunge when the skin is actively secreting after a Turkish bath, and finds its rationale doubtless in the stimulation of the nervous system, in the increase of internal circulation, and also in the renewal of activity to the cutaneous circulation after the momentary contraction of blood-vessels due to the cold. The popular belief, doubtless, rests on the injurious effects which may be induced by the bath in one who does not resort to it immediately, but allows time for the effects of fatigue to show themselves on the muscles and nerves and for the surface of the body to get cool. Taken then, the bath is more likely to depress than to stimulate; there is less power of reaction and greater liability to internal inflammations. At such a time a warm bath rather than a cold one is more suitable and more safe. It has been suggested, however, that the practice of indulging in a bath after violent exercise may initiate renal disease. Of this there is no evidence. The transitory albuminuria observed after prolonged cold baths may indicate the disturbance in the renal circulation which ensues upon them; but these cases are in a different category from those to which we are now alluding, nor are we aware of any facts to prove that, even in them, Bright's disease has been developed in consequence of the transient departure from the normal. Lastly, it must be remembered that those indulging in athletic exercises of all kinds are presumably sound in heart as well as limb, and that such persons may take with impunity and, indeed, with benefit measures which would be distinctly harmful to the weakly."

Recreations for City Children.—Struck by the fact that the present crowding of houses in cities is unfavorable to the free exercise of children in play such as prevailed when man lived in a more scattered way, Prof. S. T. Skidmore, of Philadelphia, has sketched a scheme for the evolution of a new system of play. Even under the prevailing conditions, the way for the development of proper play, he believes, is just as open as for anything else, while its development requires the genius of thought and well-directed business enterprise. The author's plan rests upon the principle that "play is the exercise of the faculties as such; the doing is for the sake of the doing. It is Nature working toward her end in the child by prompting to the free, objectless exercise of those expansile powers which he sees at work in adult life. If he sees the way open and he has the needful facilities, he will imitate so closely, in miniature, the activities of the age to which he belongs, that his play will not be a nuisance, so discordant as to be intolerable; but if left entirely with his own resources, he can do nothing else than drag forward those relics of barbaric play which have descended to him by tradition from barbaric children, who copied the simple

rudenesses of their own barbaric times." So Mr. Skidmore would find his substitute in diversion derived from pursuits, achievements, and habits of the children's elders. "In an age of mechanic arts and commerce, of which the great men are inventors, authors, business organizers, engineers, and self-made millionaires, with the eyes of youth trained upon them in admiration, interested in everything that pertains to their history, and eager to imitate them, it is nonsense to suppose that the boys can not be made to belong to such an age in their play as exactly as the men do in their work." The new play must call forth the constructive faculties, and manual training is held up as an element of it.

Propagation of Cholera.—The report of the Cholera Quarantine Board at Alexandria, Egypt, after reviewing the work of contending against the epidemic last season, inquires into the origin of the disease. According to information received in Egypt, the first cases of cholera were observed among the Yemen pilgrims immediately on their arrival at Mecca. It is known that cholera must have been prevailing in the Yemen as lately as the end of 1892. Discussions on the subject in the past have usually been very unsatisfactory and the conclusions very indefinite. The serious fact remains that cholera epidemics among the pilgrims annually collected at Mecca are of very frequent occurrence and are a standing menace to Egypt and Europe. Four times within the last twelve years the disease might have been introduced by the pilgrims into Egypt or Europe, or both, and the experience of France and Spain has shown how easily it might become endemic. The endeavors of the Quarantine Board have fortunately been successful in stamping out cholera before the pilgrims reached Europe.

NOTES.

Boards for making coffins are exported in large numbers from Upper Tonkin to the province of Mongtze, in China. The trees from which they are made are not growing in the woods, but are deposited in what a French writer calls tree mines—that is, they are buried in a sandy soil at a depth of from seven to twenty-five feet, in good preservation, and some of them more than three feet in diameter. They probably once grew, judging from the character and position of the trunks, in a large forest which was buried by an earthquate or some other similar catastrophe. It is impossible to determine when the event took place, for no record of such a phenomenon is preserved; but the time can not have been extremely remote, for the upper limbs of many of the trees are still whole. The tree is a kind of pine, very pitchy, and therefore very durable; whence the demand for it.

The vibrations of a building or a bridge may be registered by means of a bright gem which will reflect a ray of light upon a sensitive hand moved by clock work. It has recently been found by Dr. Steiner, of Hungary, that the vibrations of a stone bridge while a railroad train is passing over it at a speed of twenty-five miles an hour are much more extensive than had been supposed, and in the fact this author finds a new source of danger.

Acceding to a request of the Alpine Club, the Government of India has authorized its officers who are in a position to make them to institute observations of the movements of glaciers in the Himalayas.

A considerable quantity of evidence has been collected of a power in tobacco to destroy the micro-organism of cholera. Herr Wernicke wrapped cultures in cigars, inoculated them with sterile dry and moist unsterilized leaves, immersed them in infusions, and enveloped them in tobacco smoke; and in every case they disappeared in a few hours, except in a five-per-cent infusion, when they lived thirty-three days. Tarsinari found that they were usually killed after thirty minutes' exposure to tobacco fumes. Immunity from cholera has been observed among workmen in tobacco factories.

The collected works of the chemist Jean Servais Stas are to be published as a mark of honor to his memory, under the direction of MM. Spring and Defaire, in three quarto volumes of about five hundred or six hundred pages each. The first volume will contain the memoirs and papers relating particularly to the determination of atomic weights; the second, notes, reports, and lectures; and the third, posthumous works, relating especially to spectroscopic researches.

Certain concretions or "coal balls" found in the lower coal measures were the subject of a recent paper by H. B. Stocks in the Edinburgh Royal Society. They are remarkable for the perfect condition in which their fossil contents are preserved. Chemically they consist of carbonate of lime and iron pyrites in equal proportions. The perfect condition of the fossilized plant cells and fibers indicates that decay and petrifaction must have gone on simultaneously, and Mr. Stocks accounts for them by supposing that by the process of osmosis water containing

the usual quantity of calcium sulphate in solution passes through the vegetable tissues of the plant and sets up a series of chemical changes resulting in the formation of carbonate of lime and iron pyrites.

Indolence is declared a disease, and its pathology is studied, in the Medical Record. It is found an almost constant indication in albuminuria and diabetes. Malarial fevers induce it, and it is a frequent effect of dyspepsias and indigestions. It is a characteristic in neurasthenia so generally that it is usually safe to say that an indolent person is neurasthenic to a certain extent. Hence, in cases of chronic indolence, the counsels of a physician are often more in place than those of a moralist.

It has been observed that some of the batrachians have a preference for one or the other of the mediums in which they are capable of existing—the triton, for instance, and the salamander for air, while the frog chooses either, according to the atmospheric conditions, although their morphology points to a descent from a common stock. The subject has been studied by M. Dissart, who, finding that aquatic species transpire more and respire less than land species, concludes that an antagonism exists between the two functions by the operation of which the habitat is determined. If an aquatic species is placed in air, its transpiration is augmented, and it returns to the water to counteract the increase; while if an air species is kept in water, its respiration diminishes and it is obliged to return to the air in order to prevent asphyxia.

The *telephotos* is the name of a new method of electric signaling by night and day, invented by C. V. Boughton, of Buffalo, N. Y. The theory of it is the production by electricity upon a shaft of incandescent lamps of the symbols of the Morse alphabet and numerals, in dashes five feet long, made with ten lighted lamps, and dots three inches long each, made with one lighted lamp, with unlighted intervals of five feet between each, which would bring under the eye the complete symbol at once. It is intended for use at any points within vision between which the laying of telegraph wires is impossible or impracticable.

The United States Commission of Fish and Fisheries is engaged in an inquiry, under the direction of George F. Kunz, concerning the locations, yield, and proper protection of fresh-water pearl fisheries in the United States, and in connection with it has sent out a list of questions embracing the subjects of the nature of the stream in which the pearl-bearing mussels are found, kind of bottom, character of water; geological character of the district as to rock, soil, etc.; general abundance of mussels; size, shape, and position of the mussel beds; local names of mussels; habits of mussels; enemies and fatalities to which mussels are exposed; nature and extent of destruction by muskrats, hogs, freshets, etc.; size, shape, and color of mussels; species of mussels in which pearls are most common; proportion of mussels in which pearls occur; sizes or other peculiarities of shells in which pearls are found; nature and origin of pearls; position in mussels; size, shape, and color of pearls; and relative value of pearls of different sizes, shapes, and colors. Other questions relate to the markets and prices for pearls, the method, history, and statistics of the fisheries, the uses made of the mussels after the pearls are taken out, and the exhaustion and replenishment of mussel beds.

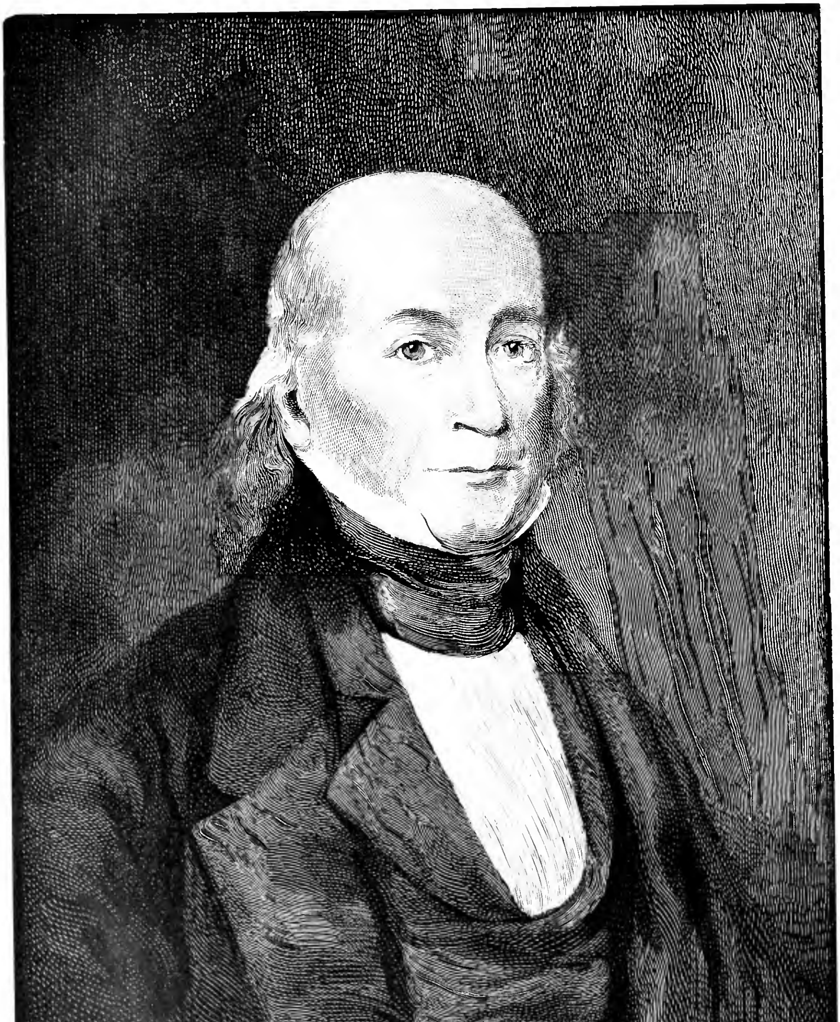
An exceedingly full and rich herbarium and botanical library has been given by Captain John Donnell Smith, of Baltimore, to Johns Hopkins University, on condition that a suitable building be provided for it. The flowering and lower plants of the whole world are represented in the herbarium, which includes Kerner's collection of Austro-Hungarian plants, about thirty individual collections of North American plants, more than a dozen of Central American and Mexican, Lehmann's and nine other collections of South American plants, and representatives from Egypt, Abyssinia, and other parts of the world.

The palms are said to be the plants possessing the largest leaves. The Quaja palm of the Amazons has leaves approaching fifty feet in length by sixteen feet in breadth. The leaves of some palms in Ceylon are more than eighteen feet long and nearly as wide, and are used by the natives for making tents. The cocoa palm has leaves nearly thirty feet long. In other families than the palms, the parasol magnolia of Ceylon forms leaves large enough to shelter fifteen or twenty persons. One of these leaves, carried to England as a specimen, measured nearly thirty-five feet. The largest leaves grown in temperate climates are those of the exotic *Victoria regia*, which sometimes reach about seven feet in diameter.

Italian grape culturists are now making a very nice illuminating oil from grape seeds, from which they get a product of from ten to fifteen per cent. It is clear, colorless, and inodorous, and burns without smoke.

OBITUARY NOTES.

Dr. D. Scott Moncrieff, of Harvard University, died in Eastern Siberia in August, 1893, while on a journey of exploration and ethnological research. He left a Gilyuk village, near the mouth of the Amur River, for a sail in an open boat on the 11th, and his body was found two weeks afterward on the coast of Sakhalin.



GERARD TROOST.

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NEW CHAPTERS IN THE WARFARE OF SCIENCE.

XIX.—FROM CREATION TO EVOLUTION.

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PART IV.

THE FINAL EFFORT OF THEOLOGY.

THE Origin of Species had come into the theological world like a plow into an ant-hill. Everywhere those who were thus rudely awakened from their old comfort and repose had swarmed forth angry and confused. Reviews, sermons, books light and heavy, came flying at the new thinker from all sides.

The keynote was struck at once in the Quarterly Review by Wilberforce, Bishop of Oxford. He declared that Darwin was guilty of "a tendency to limit God's glory in creation"; that "the principle of natural selection is absolutely incompatible with the word of God"; that it "contradicts the revealed relations of creation to its Creator"; that it is "inconsistent with the fullness of his glory"; that it is "a dishonoring view of Nature"; and the bishop ended by pointing Darwin's attention to "a simpler explanation of the presence of these strange forms among the works of God," that cause being—"the fall of Adam." Nor did the bishop's services end here; at the meeting of the British Association for the Advancement of Science he again disported himself in the tide of popular applause. Referring to the ideas of Darwin, who was absent on account of illness, the bishop in a public speech congratulated himself that he was not descended from a monkey. The reply came from Huxley, who said in substance: "If I had to choose, I would prefer to be a descendant of

a humble monkey rather than of a man who employs his knowledge and eloquence in misrepresenting those who are wearing out their lives in the search for truth."

This shot reverberated through England, and indeed through other countries.

The utterances of the most brilliant prelate of the Anglican Church received a sort of antiphonal response from the leaders of the English Catholics. In an address before the Academia, which had been organized to combat "science falsely so called," Cardinal Manning declared his "abhorrence" of the new view of Nature, and described it as "a brutal philosophy—to wit, there is no God, and the ape is our Adam."

These attacks from such eminent sources set the clerical fashion which prevailed for several years. One eminent clerical reviewer, in spite of Darwin's thirty years of quiet labor, and in spite of the powerful summing up of his book, prefaced a diatribe by saying that Darwin "might have been more modest had he given some slight reason for dissenting from the views generally entertained." Another distinguished clergyman, vice-president of a Protestant institute to combat "dangerous" science, declared Darwinism "an attempt to dethrone God." Another critic spoke of persons accepting the Darwinian views as "under the frenzied inspiration of the inhaler of mephitic gas," and of Darwin's argument as "a jungle of fanciful assumption." Another spoke of Darwin's views as suggesting that "God is dead," and declared that Darwin's work "does open violence to everything which the Creator himself has told us in the Scriptures of the methods and results of his work." Still another theological authority declares: "If the Darwinian theory is true, Genesis is a lie, the whole framework of the book of life falls to pieces, and the revelation of God to man, as we Christians know it, is a delusion and a snare." Another, who had shown excellent qualities as an observing naturalist, declared the Darwinian view "a huge imposture from the beginning."

Echoes came from America. One review, the organ of the most widespread of American religious sects, declared that Darwin "was attempting to befog and to pettifog the whole question"; another declared Darwin's views "the only form of infidelity from which Christianity had anything to fear"; another, representing the American branch of the Anglican Church, poured contempt over Darwin as "sophistical and illogical," and then plunged into an exceedingly dangerous line of argument in the following words: "If this hypothesis be true, then is the Bible an unbearable fiction; . . . then have Christians for nearly two thousand years been duped by a monstrous lie. . . . Darwin requires us to disbelieve the authoritative word of the Creator." A lead-

ing journal representing the same church took pains to show the evolution theory to be as contrary to the explicit declarations of the New Testament as to those of the Old, and said: "If we have all, men and monkeys, oysters and eagles, developed from an original germ, then is St. Paul's grand deliverance—'All flesh is not the same flesh; there is one kind of flesh of men, another of beasts, another of fishes, and another of birds'—untrue."

Another echo came from Australia, where Dr. Perry, Lord Bishop of Melbourne, in a most bitter book on Science and the Bible, declared that the obvious object of Chambers, Darwin, and Huxley is "to produce in their readers a disbelief of the Bible."

Nor was the older branch of the Church to be left behind in this chorus. Bayma, in the Catholic World, declared, "Mr. Darwin is, we have reason to believe, the mouthpiece or chief trumpeter of that infidel clique whose well-known object is to do away with all idea of a God."

Worthy of especial note as showing the determination of the theological side at this period is the foundation of sacro-scientific organizations to combat the new ideas. First to be noted is the Academia, planned by Cardinal Wiseman. In a circular letter the cardinal sounded an alarm and summed up by saying, "Now it is for the Church, which alone possesses divine certainty and divine discernment, to place itself at once in the front of a movement which threatens even the fragmentary remains of Christian belief in England." The necessary permission was obtained from Rome, the Academia was founded, and the "divine discernment" of the Church was seen in the utterances which came from it, such as those of Cardinal Manning, which every thoughtful Catholic would now desire to recall, and in the violent diatribes of Dr. Laing, which only aroused laughter on all sides. A similar effort was seen on the Protestant side; the Victoria Institute was created, and perhaps the most noted utterance which ever came from it was the declaration of its vice-president, the Rev. Walter Mitchell, that "Darwinism endeavors to dethrone God." *

* For Wilberforce's article, see Quarterly Review, July, 1860. For the reply of Huxley to the bishop's speech I have relied on the account given in Quatrefages, who had it from Carpenter; a somewhat different version is given in the Life and Letters of Darwin. For Cardinal Manning's attack, see Essays on Religion and Literature, London, 1865. For the review articles, see the Quarterly already cited, and that for July, 1874; also the North British Review, May, 1860; also, F. O. Morris's letter in the Record, reprinted at Glasgow, 1870; also the Addresses of Rev. Walter Mitchell before the Victoria Institute, London, 1867; also Rev. B. G. Johns, Moses not Darwin, a Sermon, March 31, 1871. For the earlier American attacks, see Methodist Quarterly Review, April, 1871; the American Church Review, July and October, 1865, and January, 1866. For the Australian attack, see Science and the Bible, by the Right Reverend Charles Perry, D. D., Bishop of Melbourne, London,

In France the attack was even more violent. Fabre d'Envieu brought out the heavy artillery of theology, and in a long series of elaborate propositions demonstrated that any other doctrine than that of the fixity and persistence of species is absolutely contrary to Scripture. The Abbé Désorges, a former Professor of Theology, stigmatized Darwin as a "pedant," and evolution as "gloomy"; Monseigneur Ségur, referring to Darwin and his followers, declared: "These infamous doctrines have for their only support the most abject passions. Their father is pride, their mother impurity, their offspring revolutions. They come from hell and return thither, taking with them the gross creatures who blush not to proclaim and accept them."

In Germany the attack, if less declamatory, was no less severe. Catholic theologians vied with Protestants in bitterness. Prof. Michelis declared Darwin's theory "a caricature of creation." Dr. Hagermann asserted that it "turned the Creator out of doors." Dr. Schund insisted that "every idea of the Holy Scriptures, from the first to the last page, stands in diametrical opposition to the Darwinian theory"; and, "if Darwin be right in his view of the development of man out of a brutal condition, then the Bible teaching in regard to man is utterly annihilated." Rougemont at Stuttgart called for a crusade against the obnoxious doctrine. Luthardt, Professor of Theology at Leipsic, declared: "The idea of creation belongs to religion and not to natural science; the whole superstructure of personal religion is built upon the doctrine of creation"; and he showed that the evolution theory is in direct contradiction to Holy Writ.

But in 1863 came an event which brought serious confusion to the theological camp: Sir Charles Lyell, the most eminent of living geologists, a man of deeply Christian feeling and of exceedingly cautious and conservative temper, who had opposed the evolution theory of Lamarck and declared his adherence to the idea of successive creations, then published his work on the Antiquity of Man, and in this and other utterances showed himself a complete though unwilling convert to the fundamental ideas of Darwin. The blow was serious in many ways, and especially so in two—first, as withdrawing all foundation in fact from the scriptural chronology, and secondly, as discrediting the creation theory. The blow was not indeed unexpected; in various review articles against the Darwinian theory there had been appeals to Lyell, at times almost piteous, "not to flinch from the truths he had formerly proclaimed."

1869. For Bayma, see the Catholic World, xxvi, 782. For the Academia, see Essays edited by Cardinal Manning, above cited; and for the Victoria Institute, see Scientia Scientiarum, by a member of the Victoria Institute, London, 1865.

But Lyell, like the honest man he was, yielded unreservedly to the mass of new proofs arrayed on the side of evolution as against that of creation.

At the same time came Huxley's Man's Place in Nature, giving new and most cogent arguments in favor of evolution by natural selection.

In 1871 was published Darwin's Descent of Man. Its doctrine had indeed been anticipated by critics of his previous books, but it none the less gave a great stir to the opposite side; again the opposing army trooped forth, though evidently with much less heart than before. A few were very violent. In the Dublin University Magazine Mr. Darwin was charged, after the legendary Hibernian fashion, with seeking "to displace God by the unerring action of vagary," and as being "resolved to hunt God out of the world." But most notable from this side of the older Church was the elaborate answer to Darwin's book by the eminent French Catholic physician, Dr. Constantin James. In his work, On Darwinism, or the Man-Ape, published at Paris in 1877, Dr. James not only refuted Darwin scientifically but poured contempt on his book, calling it "a fairy tale," and hesitating to take it seriously, since a work "so fantastic and so burlesque" was, doubtless, only a huge joke, like Erasmus's Praise of Folly, or Montesquieu's Persian Letters. The princes of the Church were delighted. The Cardinal Archbishop of Paris assured the author that the book had become his "spiritual reading," and begged him to send a copy to the Pope himself. His Holiness, Pope Pius IX, acknowledged the gift in a remarkable letter. He thanked his dear son, the writer, for the book in which he "refutes so well the aberrations of Darwinism. . . . A system," he adds, "which is repugnant at once to history, to the tradition of all peoples, to exact science, to observed facts, and even to Reason herself, would seem to need no refutation, did not alienation from God and the leaning toward materialism, due to depravity, eagerly seek a support in all this tissue of fables. . . . And, in fact, pride, after rejecting the Creator of all things and proclaiming man independent, wishing him to be his own king, his own priest, and his own God—pride goes so far as to degrade man himself to the level of the unreasoning brutes, perhaps even of lifeless matter, thus unconsciously confirming the Divine declaration, *When pride cometh, then cometh shame.* But the corruption of this age, the machinations of the perverse, the danger of the simple, demand that such fancies, altogether absurd though they are, should—since they borrow the mask of science—be refuted by true science." Wherefore the Pope thanks Dr. James for his book, "so opportune and so perfectly appropriate to the exigencies of our time," and bestows on him the apostolic benediction. Nor was

this brief all. With it there came a second, creating the author an officer of the Papal Order of St. Sylvester. The Cardinal Archbishop assured the astonished physician that such a double honor of brief and brevet was perhaps unprecedented, and suggested only that in a new edition of his book he should "insist still a little more on the relation existing between the narratives of Genesis and the discoveries of modern science, in such fashion as to convince the most incredulous of their perfect agreement." The prelate urged also a more dignified title. The proofs of this new edition were accordingly all submitted to his Eminence, and in 1882 it appeared as Moses and Darwin: the Man of Genesis compared with the Man-Ape, or Religious Education opposed to Atheistic. No wonder the cardinal embraced the author, thanking him in the name of science and religion. "We have at last," he declared, "a handbook which we can safely put into the hands of youth."

Scarcely less vigorous were the champions of English Protestant orthodoxy. In an address at Liverpool, Mr. Gladstone remarked: "Upon the grounds of what is termed evolution God is relieved of the labor of creation; in the name of unchangeable laws he is discharged from governing the world"; and, when Herbert Spencer called his attention to the fact that Newton with the doctrine of gravitation and with the science of physical astronomy is open to the same charge, Mr. Gladstone retreated in the Contemporary Review under one of his characteristic clouds of words. The Rev. Dr. Coles, in the British and Foreign Evangelical Review, declared that the God of evolution is not the Christian's God. Bangor, Dean of Chichester, in a sermon preached before the University of Oxford, pathetically warned the students that "those who refuse to accept the history of the creation of our first parents according to its obvious literal intention, and are for substituting the modern dream of evolution in its place, cause the entire scheme of man's salvation to collapse." Dr. Pusey also came into the fray with most earnest appeals against the new doctrine, and the Rev. Gavin Carlyle was most earnest on the same side. The Society for Promoting Christian Knowledge published a book by the Rev. Mr. Birks, in which the evolution doctrine was declared to be "flatly opposed to the fundamental doctrine of creation." Even the London Times admitted a review of Darwin's Descent of Man, in which it was spoken of as an "utterly unsupported hypothesis," full of "unsubstantiated premises, cursory investigations, and disintegrating speculations," and Darwin himself was declared "reckless and unscientific." *

* For the French theological opposition to the Darwinian theory, see Pozzy, La Terre et le Récit Biblique de la Création, 1874, especially pp. 353, 363; also, Félix Ducane,

But it was noted that this second series of attacks, on the Descent of Man, differed in one remarkable respect—so far as England was concerned—from those which had been made over ten years before on the Origin of Species. While everything was done to discredit Darwin, to pour contempt over him, and even, of all things in the world, to make him—the gentlest of mankind, only occupied with the scientific side of the problem—"a persecutor of Christianity," while his followers were represented more and more as charlatans or dupes, there began to be in the most influential quarters careful avoidance of the old argument that evolution—even by natural selection—contradicts Scripture. It began to be felt that this was dangerous ground. The defection of Lyell had, perhaps, more than anything else, started the question among theologians who had preserved some equanimity, "What if, after all, the Darwinian theory should prove to be true?" Recollections of the position in which the Roman Church found itself after the establishment of the doctrines of Copernicus and Galileo naturally came into the minds of the more thoughtful. In Germany this consideration does not seem to have occurred at quite so early a day. One eminent Lutheran clergyman at Magdeburg called on his hearers to choose between Darwin and religion; Delitszch, in his new commentary on Genesis, attempted to bring science back to recognize human sin as an important factor in creation; Prof. Heinrich Ewald, while carefully avoiding any sharp conflict between the scriptural doctrine and evolution, comforted himself by pouring contempt over Darwin and his followers; Christlieb, in his address before the Evangelical Alliance at New York, 1873, simply took the view that the

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Études sur le Transformisme, 1876, especially pp. 107 to 119. As to Fabre d'Envieu, see especially his Proposition xliii. For the Abbé Desorges, "former Professor of Philosophy and Theology," see his Erreurs Modernes, Paris, 1878, pp. 677 and 595 to 598. For Monseigneur Ségur, see his La Foi devant la Science Moderne, sixth ed., Paris, 1874, pp. 23, 34, etc. For Herbert Spencer's reply to Mr. Gladstone, see his Study of Sociology; for the passage in the Dublin Review, see the issue for July, 1871. For the review in the London Times, see Nature for April 20, 1871. For Gavin Carlyle, see The Battle of Unbelief, 1870, pp. 86 and 171. For the attacks by Michelis and Hagermann, see Natur und Offenbarung, Münster, 1861 to 1869. For Schund, see his Darwin's Hypothese und ihr Verhältniss zu Religion und Moral, Stuttgart, 1869. For Luthardt, see Fundamental Truths of Christianity, translated by Sophia Taylor, second ed., Edinburgh, 1869. For Rougemont, see his Der Mensch und der Affe, Stuttgart, 1863, translated into German. For Constantin James, see his Mes Entretiens avec l'Empéreur Don Pédro sur le Darwinisme, Paris, 1888, where the papal briefs are printed in full. For the English attacks on Darwin's Descent of Man, see the Edinburgh Review, July, 1871, and elsewhere; the Dublin Review, July, 1871; the British and Foreign Evangelical Review, April, 1886. See also The Scripture Doctrine of Creation, by the Rev. T. R. Birks, London, 1873, published by the S. P. C. K. For Dr. Pusey's attack, see his Unscience not Science, adverse to Faith, 1878; also, Darwin's Life and Letters, vol. ii, pp. 411, 412.

tendencies of the Darwinian theory were "toward infidelity," but declined to make any serious battle on biblical grounds; the Jesuit, Father Pesch, in Holland, drew up in Latin in due array, after the old scholastic manner, a sort of general indictment of evolution, of which one must say that it was interesting—as interesting as the display of a troop in chain armor and with cross-bows on a nineteenth-century battlefield.

From America there came new echoes. Among the myriad attacks on the Darwinian theory by Catholics and Protestants two should be especially mentioned. The first of these was by Dr. Noah Porter, President of Yale College, an excellent scholar, an interesting writer, a noble man, broadly tolerant, combining in his thinking a curious mixture of radicalism and conservatism. While giving great latitude to the evolutionary teaching in the university under his care, he felt it his duty upon one occasion to avow his disbelief in it; but he was very careful not to suggest any necessary antagonism between it and the Scriptures. He confined himself mainly to pointing out the tendency of the evolution doctrine in this form toward agnosticism and pantheism. To those who knew and loved him and had noted the genial way in which by wise neglect he had allowed scientific studies to flourish at Yale, there was an amusing side to all this. Within a stone's throw of his college rooms was the Museum of Paleontology, in which Prof. Marsh had laid side by side, among other evidences of the new truth, that wonderful series of specimens showing the evolution of the horse from the earliest form of the animal, "not larger than a fox, with five toes," through the whole series up to his present form and size—that series which the most eminent living exponent of the Darwinian view has declared an absolute proof of the existence of natural selection as an agent in evolution. In spite of the veneration and love which all Yale men felt for President Porter, it was hardly to be expected that these particular arguments of his would have much permanent effect upon them when there was constantly before their eyes so convincing a refutation.

But a far more determined and bitter opponent was the Rev. Dr. Hodge, of Princeton; his anger toward the evolution doctrine seemed to madden him: he declared it thoroughly "atheistic"; he insisted that Christians "have a right to protest against the arraying of probabilities against the clear evidence of the Scriptures"; he even censured so orthodox a writer as the Duke of Argyll, and declared that the Darwinian theory of natural selection is "utterly inconsistent with the Scriptures," and that "an absent God, who does nothing, is to us no God"; that "to ignore design as manifested in God's creation is a theory which attempts to dethrone God"; that "a denial of design in Nature is virtually

a denial of God"; and that "no teleologist can be a Darwinian." Even more bitter was another of the leading authorities at the same university—the Rev. Dr. Duffield. He declared war not only against Darwin but even against men like Asa Gray, Le Conte, and others, who had attempted to reconcile the new theory with the Bible; he insisted that "evolutionism and the scriptural account of the origin of man are irreconcilable"—that the Darwinian theory is "in direct conflict with the teaching of the apostle, 'All scripture is given by inspiration of God'"; he points out, in opposition both to Darwin's Descent of Man and Lyell's Antiquity of Man, that in the Bible "the genealogical links which connect the Israelites in Egypt with Adam and Eve in Eden are explicitly given." These utterances of Prof. Duffield culminated in a declaration which deserves to be cited as showing that a Presbyterian minister can "deal damnation round the land" *ex cathedra* in a fashion quite equal to that of popes and bishops. It is as follows: "If the development theory of the origin of man," wrote Dr. Duffield in the Princeton Review, "shall in a little while take its place—as doubtless it will—with other exploded scientific speculations, then they who accept it with its proper logical consequences will in the life to come have their portion with those who in this life 'know not God and obey not the gospel of his Son.'"

Fortunately, at about the time when Darwin's Descent of Man was published, there had come into Princeton University a "*deus ex machina*" in the person of Dr. James McCosh. Assuming the presidency, he at once took his stand against teachings so dangerous to Christianity as those of Drs. Hodge, Duffield, and their *confrères*. In one of his personal confidences he has let us into the secret of this matter. With that hard Scotch sense which had won the applause of Thackeray in his well-known verses, he saw that the most dangerous thing which could be done to Christianity at Princeton was to reiterate in the university pulpit, week after week, solemn declarations that if evolution by natural selection, or indeed evolution at all, be true, the Scriptures are false. McCosh tells us that he saw that this was the certain way to make the students unbelievers; he therefore not only gave a check to this dangerous preaching but preached an opposite doctrine. With him began the inevitable compromise, and, in spite of mutterings against him as a Darwinian, he carried the day. Whatever may be thought of the general system of philosophy which he has advocated, no one can deny the great service he rendered in neutralizing the teachings of his predecessors and colleagues—so dangerous to all that is essential in Christianity.

Other divines of strong sense in other parts of the country began to take similar ground—namely, that men could be Christians

and at the same time believe in the Darwinian theory. There appeared, indeed, here and there, curious discrepancies; thus in 1873 the Monthly Religious Magazine of Boston congratulated its readers that the Rev. Mr. Burr had "demolished the evolution theory, knocking the breath of life out of it and throwing it to the dogs." This amazing performance by "the Rev. Mr. Burr" was repeated in a different form and in a very striking way by Bishop Keener before the Œcumenical Council of Methodism at Washington in 1891. In what is described in the newspapers as an "admirable speech," he refuted evolution doctrines by saying that evolutionists had only to make a journey of twelve hours from the place in which he was then standing and find together the bones of the muskrat, the opossum, the coprolite, and the ichthyosaurus. He asserted that Agassiz—whom the good bishop, like so many others, seemed to think an evolutionist—when he visited these beds near Charleston, declared: "These old beds have set me crazy; they have destroyed the work of a lifetime"; and the Methodist prelate ended by saying: "Now, gentlemen, brethren, take these facts home with you; get down and look at them. This is the watch that was under the steam hammer—the doctrine of evolution; and this steam hammer is the wonderful deposit of the Ashley beds."

Exhibitions like these availed little. While the good bishop amid vociferous applause thus made comically evident his belief that Agassiz was a Darwinian and a coprolite an animal, scientific men were recording in all parts of the world facts confirming the dreaded theory of an evolution by natural selection. While the Rev. Mr. Burr was so loudly praised for "chopping up Darwinism and throwing it to the dogs," Marsh was completing his series leading from the five-toed ungulates to the horse; while Dr. Tayler Lewis at Union, and Drs. Hodge and Duffield at Princeton, were showing that if evolution is true the biblical accounts are false, the indefatigable Yale professor was showing his cretaceous birds, and among them *Hesperornis* and *Ichthyornis* with teeth; while in Germany Luthardt, Schund, and their compeers were demonstrating that Scripture requires a belief in special and separate creations, the *Archæopteryx*, showing a most remarkable connection between birds and reptiles, was discovered; while in France Monseigneur Ségur and others were indulging in diatribes against "a certain Darwin," Gaudry and Filhol were discovering a striking series of "missing links" among the carnivora.

In view of the proofs accumulating in favor of the new evolutionary hypothesis, the change in the tone of controlling theologians was now rapid. From all sides came evidences of desire to compromise with the theory. The strict adherents of the biblical text pointed significantly to the texts in Genesis in which the

earth and sea were made to bring forth birds and fishes, and man was created out of the dust of the ground. Men of broader mind like Kingsley and Farrar, and English and American broad churchmen generally, took ground directly in Darwin's favor. Even Whewell took pains to show that there might be such a thing as a Darwinian argument for design in Nature; and the Rev. Samuel Houghton, of the Royal Society, gave interesting suggestions of a teleological evolution.

Both the great English universities received the new teaching as a leaven; at Oxford, in the very front of the High Church party at Keble College, was elaborated a statement that the evolution doctrine is "an advance in our theological thinking"; and Temple, Bishop of London, perhaps the most influential thinker at present in the Anglican episcopate, accepted the new revelation in the following words: "It seems something more majestic, more befitting Him to whom a thousand years are as one day, thus to impress his will once for all on his creation, and provide for all the countless varieties by this one original impress, than by special acts of creation to be perpetually modifying what he had previously made."

In Scotland the Duke of Argyll, head and front of the orthodox party, dissenting in many respects from Darwin's full conclusions, made concessions which disorganized the old position.

Curiously enough, from the Roman Catholic Church, bitter as some of its writers had been, now came argument to prove that the Catholic faith does not prevent any one "from holding the Darwinian theory," and especially a declaration from an authority eminent among American Catholics—a declaration which has a very curious sound, but which it would be ungracious to find fault with—that "the doctrine of evolution is no more in opposition to the doctrine of the Catholic Church than is the Copernican theory or that of Galileo."

Here and there, indeed, men of science like Dawson, Mivart, and Wigand, in view of theological considerations, have sought to make conditions; but the current is too strong, and we find eminent theologians in every country ready to accept natural selection as at least a very important part in the mechanism of evolution.

At the death of Darwin it was felt that there was but one place in England where his body should be laid, and that this place was next the grave of Sir Isaac Newton in Westminster Abbey. The noble address of Canon Farrar at his funeral was echoed from many pulpits in Europe and America, and theological opposition as such was ended. Occasionally there came, it is true, a survival of the old feeling; the Rev. Dr. Laing referred to the burial of Darwin in Westminster Abbey as "a proof that Eng-

land is no longer a Christian country," and added that this burial was a desecration—that this honor was given him because he had been "the chief promoter of the mock doctrine of evolution of the species and ape descent of man"; and this was echoed in Scotland by the Rev. Dr. Lee, who was pleased to call Darwin and his followers "gospelers of the gutter."

Still another of these belated prophets was, of all men, Thomas Carlyle. Soured and embittered, in the same spirit which led him to find more heroism in a marauding Viking or in one of Frederick the Great's generals than in Washington, or Lincoln, or Grant, and which caused him to see in the American civil war only "the burning out of a foul chimney," he simply saw in Darwin an "apostle of dirt worship."

The last echoes of this sort of utterance reverberated between Scotland and America. In the former country, in 1885, the Rev. Dr. Lee issued a volume in which it was declared that, if the Darwinian view be true, "there is no place for God"; that "by no method of interpretation can the language of Holy Scripture be made wide enough to re-echo the orang-outang theory of man's natural history"; that "Darwinism reverses the revelation of God" and "implies utter blasphemy against the divine and human character of our Incarnate Lord." In one of the intellectual centers of America the editor of a periodical called The Christian urged frantically that "the battle be set in array, and that men find out who is on the Lord's side and who is on the side of the Devil and the monkeys."

To the honor of the Church of England it should be recorded that a considerable number of its truest men opposed such utterances as these, and that one of them—Farrar, Archdeacon of Westminster—made a protest worthy to be held in perpetual remembrance. While confessing his own inability to accept fully the new scientific belief, he said: "We should consider it disgraceful and humiliating to try to shake it by an *ad captandum* argument, or by a claptrap platform appeal to the unfathomable ignorance and unlimited arrogance of a prejudiced assembly. We should blush to meet it with an anathema or a sneer."

All opposition had availed nothing; Darwin's work and fame were secure. As men looked back over his beautiful life—simple, honest, tolerant, kindly—and thought upon the great truth he had given to mankind, all the attacks faded into nothingness.

There were indeed some dark spots, which as time goes on appear darker. At Trinity College, Cambridge, Whewell, the "omniscient," author of the History of the Inductive Sciences, refused to allow a copy of the Origin of Species to be placed in the library. At multitudes of institutions under theological control—Catholic as well as Protestant—attempts were made to

stamp out or to stifle evolutionary teaching. Especially was this true for a time in America, and the case of the American College at Beyrout, where nearly all the younger professors were dismissed for adhering to Darwin's views, is worthy of remembrance. The treatment of Dr. Winchell at the Vanderbilt University in Tennessee showed the same spirit; one of the truest of men, devoted to science but of deeply Christian feeling, he was driven forth for views which centered in the Darwinian theory.

Still more striking was the case of Dr. Woodrow. He had, about 1857, been appointed to a professorship of Natural Science as connected with Revealed Religion, in the Presbyterian Seminary at Columbia, South Carolina. He was a devoted Christian man, and his training had led him to accept the Presbyterian standards of faith. With great gifts for scientific study he visited Europe, made a most conscientious examination of the main questions under discussion, and adopted the chief points in the doctrine of evolution by natural selection. A struggle soon began. A movement hostile to him grew more and more determined, and at last, in spite of the efforts made in his behalf by the directors of the seminary and by a large and broad-minded minority in the representative bodies controlling it, an orthodox storm, raised by the delegates from various Presbyterian bodies, drove him from his post. Fortunately, he was received into a professorship at the University of South Carolina, where he has since taught with more power than ever before.

This testimony to the faith by American provincial Protestantism was very properly echoed from Spanish provincial Catholicism. In the year 1878 a Spanish colonial man of science, Dr. Chil y Marango, published a work on the Canary Islands. But Dr. Chil had the imprudence to sketch, in his introduction, the modern hypothesis of evolution, and to exhibit some proofs, found in the Canary Islands, of the barbarism of primitive man. The ecclesiastical authorities, under the lead of Bishop Urquinaona y Bidot, at once grappled with this new idea. By a solemn act they declared it "*falsa, impia, scandalosa*"; all persons possessing copies of the work were ordered to surrender them at once to the proper ecclesiastics, and the author was placed under the major excommunication, which, in those "fortunate isles," still means social isolation.

But all this opposition may be reckoned among the last expiring convulsions of the old theologic theory. Even from the new Catholic University at Washington has come an utterance in favor of the new doctrine, and in other universities in the Old World and in the New the doctrine of evolution by natural selection has asserted its right to full and honest consideration. More than this, it is clearly evident that the stronger men in the

Church have, in these latter days, not only relinquished the struggle against science in this field, but have determined frankly and manfully to make an alliance with it. In two very remarkable lectures given in 1892 at the parish church of Rochdale, Wilson, Archdeacon of Manchester, not only accepts Darwinism as true, but works it with great argumentative power into a higher view of Christianity; and what is of great significance, these sermons were published by the same Society for the Propagation of Christian Knowledge which only a few years previously had published the most bitter attacks against the Darwinian theory. So, too, during the year 1893, Prof. Henry Drummond, whose praise is in all the dissenting churches, developed a similar view most brilliantly in a series of lectures delivered before the American Chautauqua Schools, and published in one of the most widespread of English orthodox newspapers.

Whatever additional factors may be added to natural selection—and Darwin himself fully admitted that there might be others—the theory of an evolution process in the formation of the universe and of animated Nature is established, and the old theory of direct creation is gone forever. In place of it science has given us conceptions far more noble, and opened the way to an argument for design infinitely more beautiful than any ever developed by theology.*

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* For reasons of the bitterness shown regarding the Darwinian hypothesis, see Reusch, Bibel und Natur, vol. ii, pp. 46 *et seq.* For hostility in the United States toward the Darwinian theory, see among a multitude of writers the following: Dr. Charles Hodge, of Princeton, monograph, What is Darwinism? New York, 1874; also his Systematic Theology, New York, 1872, vol. ii, part 2, Anthropology. For a laudatory notice of the Rev. E. F. Burr's demolition of evolution in his book Pater Mundi, see Monthly Religious Magazine, Boston, May, 1873, p. 492; also The Light by which we see Light, or Nature and the Scriptures, Vedder Lectures, 1875, Rutgers College, New York, 1875; also Positivism and Evolutionism, in the American Catholic Quarterly, October, 1877, pp. 607, 619; and in the same number, Professor Huxley and Evolution, by Rev. A. M. Kirsch, pp. 662, 664; The Logic of Evolution, by Prof. Edward F. X. McSweeney, D. D., July, 1879, p. 561; Das Hexaemeron und die Geologie, von P. Eirich, Pastor in Albany, N. Y., Lutherischer Concordia-Verlag, St. Louis, Mo., 1878, pp. 81, 82, 84, 92–94; Evolutionism respecting Man and the Bible, by John T. Duffield, of Princeton, January, 1878, Princeton Review, pp. 151, 153, 154, 158, 159, 160, 188; A Lecture on Evolution, before the Nineteenth Century Club of New York, May 25, 1886, by ex-President Noah Porter, pp. 4, 26–29; Evolution or Not, extract in the New York Weekly Sun, October 24, 1888, concerning the removal of Rev. Dr. James Woodrow, Professor of Natural Science in the Columbia Theological Seminary. For the dealings of Spanish ecclesiastics with Dr. Chil and his Darwinian exposition, see the Revue d'Anthropologie, cited in the Academy for April 6, 1878; see also the Catholic World, xix, 433, A Discussion with an Infidel, directed against Dr. Louis Büchner and his Kraft und Stoff; also in Mind and Matter, by Rev. James Tait, of Canada, p. 66; in the third edition the author bemoans the "horrible plaudits" that "have accompanied every effort to establish man's brutal descent"; also The Church Journal, New York, May 28, 1874. For the effort in favor of a theological evolution, see Rev. Samuel Houghton, F. R. S.,

Principles of Animal Mechanics, London, 1873, preface and p. 156 and elsewhere. For details of the persecution of Drs. Winchell and Woodrow, and of the Beyrout professors, with authorities cited, see my chapter on The Fall of Man and Anthropology. For more liberal views among various religionists regarding the Darwinian theory, and for efforts to mitigate and adopt it to theological views, among the great mass of utterances see the following: Charles Kingsley, Letters to Darwin, November 18, 1859, in Darwin's Life and Letters, vol. ii, p. 82; Adam Sedgwick to Charles Darwin, December 24, 1859, see ibid., vol. ii, pp. 356–359; the same to Miss Gerard, January 2, 1860, see Sedgwick's Life and Letters, vol. ii, pp. 359, 360; the same in the Spectator, London, March 24, 1860; The Rambler, March, 1860, cited by Mivart, Genesis of Species, p. 30; The Dublin Review, May, 1860. For a review of the Origin of Species, The Christian Examiner, Boston, May, 1860, on the Origin of Species; Charles Kingsley to F. D. Maurice in 1863, see Kingsley's Life, vol. ii, p. 171; Adam Sedgwick to Livingstone (the explorer), March 16, 1865; see Life and Letters of Sedgwick, vol. ii, pp. 410–412; The Duke of Argyll, The Reign of Law, New York, pp. 16, 18, 31, 116, 117, 120, 159; Joseph P. Thompson, D. D., LL. D., Man in Genesis and Geology, New York, 1870, pp. 48, 49, 82; James Freeman Clarke, a review in the Old and New Magazine, Boston, September, 1870, on his Steps of Belief; Canon H. P. Liddon, Sermons preached before the University of Oxford, 1871, Sermon III; St. George Mivart, Evolution and its Consequences, Contemporary Review, January, 1872; British and Foreign Evangelical Review, vol. xxi, p. 18, 1872, article on The Theory of Evolution; also pp. 2, 22, 8, 9, 15; The Lutheran Quarterly, Gettysburg, Pa., April, 1872, article by Rev. Cyrus Thomas, Assistant United States Geological Survey, on The Descent of Man, pp. 214, 239, 372–376; The Lutheran Quarterly, July, 1873, article, Some Assumptions against Christianity, by Rev. C. A. Stork, Baltimore, Md., pp. 325, 326; also in same number, see a review of Dr. Burr's Pater Mundi, pp. 474, 475, and contrast with the review in the Andover Review of that period; an article in the Religious Magazine and Monthly Review, Boston, on Religion and Evolution, by Rev. S. R. Calthrop, September, 1873, p. 200; The Popular Science Monthly, January, 1874, article Genesis, Geology, and Evolution, by Rev. George Henslow—this article first appeared in his book Evolution and Religion; article by Asa Gray, Nature, London, June 4, 1874; Materialism, by Rev. W. Streissguth, Lutheran Quarterly, July, 1875, originally written in German, and translated by J. G. Morris, D. D., pp. 406, 408; Darwinismus und Christenthum, von R. Steck, Ref. Pfarrer in Dresden, Berlin, 1875, pp. 5, 6, and 26, reprinted from the Protestantische Kirchenzeitung, and issued as a tract by the Protestantenverein; Oscar Peschel, Abhandlungen zur Erd- und Völkerkunde, Leipsic, 1877, pp. 503, 504—this article first appeared in Ausland, for January 2, 1869 (Peschel was editor of this weekly magazine); Rev. W. E. Adams, article in the Lutheran Quarterly, April, 1879, on Evolution: shall it be Atheistic? John Wood, Bible Anticipations of Modern Science, 1880, pp. 18, 19, 22; Lutheran Quarterly, January, 1881, Some Postulates of the New Ethics, by Rev. C. A. Stork, D. D.; Lutheran Quarterly, January, 1882, The Religion of Evolution as against the Religion of Jesus, Prof. W. H. Wynn, Iowa State Agricultural College—this article was republished as a pamphlet; Canon Liddon, prefatory note to sermon on the Recovery of St. Thomas, pp. 4, 11, 12, 13, and 26, preached in St. Paul's Cathedral, April 23, 1882; Lutheran Quarterly, January, 1882, Evolution and the Scripture, by Rev. John A. Earnest, pp. 101, 105; Glimpses in the Twilight, by Rev. F. G. Lee, D. D., Edinburgh, 1885, especially pp. 18 and 19; the Hibbert Lectures for 1883, by Rev. Charles Beard, pp. 392, 393 *et seq.*; F. W. Farrar, D. D., Canon of Westminster, The History of Interpretation, being the Barrington Lectures for 1885, pp. 426, 427; Bishop Temple, Barrington Lectures, pp. 184–186; article Evolution, in the Dictionary of Religion, edited by Rev. William Benham, 1887; Prof. Huxley, An Episcopal Trilogy, Nineteenth Century, November, 1887—this article discusses three sermons delivered by the Bishops of Carlisle, Bedford, and Manchester, in Manchester Cathedral, during the meeting of the British Association, September, 1887; these sermons were afterward published in pamphlet form under the title, The Advance of Science; John Fiske, Darwinism, and other Essays, Boston, 1888; Harriet Mackenzie, Evolution illuminating the Bible, Lon-

NICARAGUA AND THE MOSQUITO COAST.

By ROBERT N. KEELY, Jr., M.D.

EVERY once in a while something happens to rouse Americans out of that complaisant frame of mind which has become habitual, and in which they have come to regard their imperial domain, bounded by the Great Lakes and the Rio Grande to the North and South, and the broad ocean to the East and West, as a sort of little world all to themselves, whence they could look out upon the doings beyond with a patronizing half-humorous indifference, as upon things in which they had no possible concern. A few months ago the shock was supplied by the unheralded supplication from a small island nation out in the Pacific to be taken under the broad wing of the "bird of freedom," and we awoke to the fact that perhaps in spite of ourselves and our national prejudices the logic of events had extended our zone of political influence far beyond our supposed definitive boundaries. Now comes Nicaragua, her warring factions having concluded an armistice, and asks Uncle Sam to arbitrate, with suggestions even of the advisability of an American protectorate; and it is quite possible that upon a little reflection we may discover that this fussy little republic is as essentially an integral portion of the United States of the future as if it lay between Chicago and Denver. Possessing the most practicable water way over the isthmus which divides New York from San Francisco, it may well be that the increasing necessity of a purely American ocean highway between these two ports must soon render inevitable a political predominance on our part which shall amount to virtual sovereignty over these regions.

But for a trifling incident it would never have occurred to me to go to Nicaragua. Excepting as an eligible site for a canal and

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don, 1891, dedicated to Prof. Huxley; H. E. Ryle, Hulsean Professor of Divinity at Cambridge, The Early Narratives of Genesis, London, 1892, preface, pp. vii–ix, pp. 7, 9, 11; Rev. G. M. Searle, of the Catholic University, Washington, article in the Catholic World, November, 1892, pp. 223, 227, 229, 231. For the statement from Keble College, see Rev. Mr. Illingworth, in Lux Mundi. For Bishop Temple, see citation in Laing. For the most complete and admirable acceptance of the evolution theory as lifting Christian doctrine and practice to a higher plane, with suggestions for a new theology, see two sermons by Archdeacon Wilson, of Manchester, S. P. C. K., London, and Young & Co., New York, 1893; and for a characteristically lucid statement of the most recent development of evolution doctrines, and the relations of Spencer, Weissmann, Galton, and others to them, see Lester F. Ward's Address as President of the Biological Society, Washington, 1891; also, recent articles in the leading English reviews. For a brilliant glorification of evolution by natural selection as a doctrine necessary to the highest and truest view of Christianity, see Prof. Drummond's Chautauqua Lectures, published in The British Weekly, London, from April 20 to May 11, 1893.

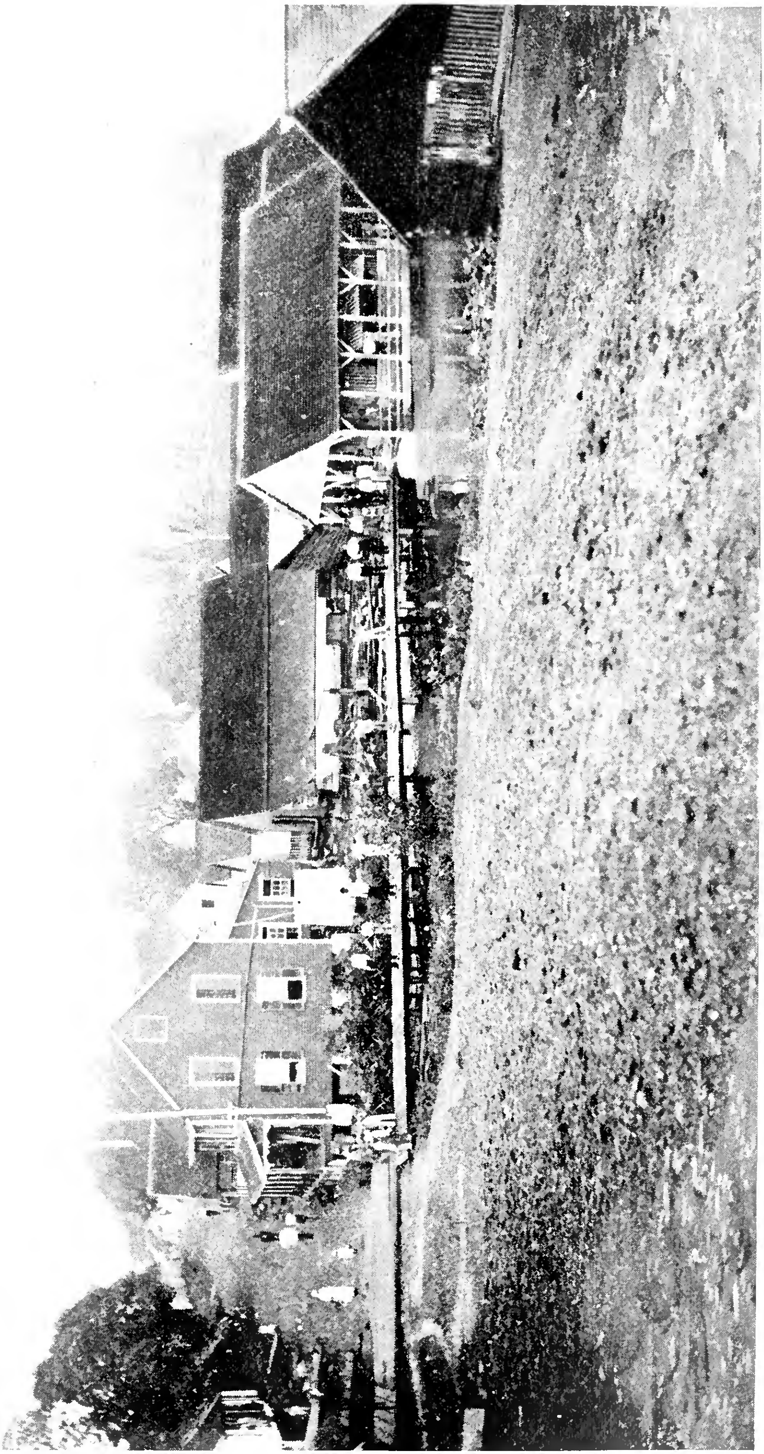

FIG. 1.—BLUEFIELDS.

as the scene of Filibuster Walker's bold exploit, the country had never been associated with my thoughts, and canals and filibusters were not in my line. I had perhaps an adumbration of centipeds and scorpions and of a people in a chronic state of revolution, which surely is not an alluring mental picture. It happened, however, that I had made preparations to go with an expedition for an extended tour of the West Indies, and was all ready to depart, when at the last moment the project was indefinitely postponed. Trunks and gripsacks were neatly packed and good-byes had been duly bidden, and here I was without any destination. In this perplexity a letter was handed me bearing an unfamiliar post-mark. Hastily tearing open the envelope, I read:

"BLUEFIELDS, NICARAGUA, *April 5, 1893.*

"MY DEAR OLD BOY: You have been wondering, no doubt, not to have heard from me all these years, and your surprise will be greater to hear from me out of this strange quarter of the globe. . . . Well, my boy, I've been at work, hard at work, and, as the world would say, I've prospered. . . . I am working a very valuable grant, covering one hundred square miles. The bottoms are rich in timber and the uplands abound with gold. Native help is plentiful and can be hired for a song and sixpence, and the mahogany can be floated all the way to the coast. I want a congenial associate, and don't know any one with whom I would rather share my good fortune. At any rate, since I heard, by the rarest chance, that you were on the way to the Caribbean, you would find a run over to view the country well worth your while, etc. H."

Here was an impulse, all that was needed—so ho! and away for Nicaragua!

THE MOSQUITOS.—The 10th of May, 1893, found us aboard a little schooner from Greytown bound for Bluefields, the capital of that singular and little-known people the Mosquito Indians.

The portion of the Caribbean littoral commonly known as the Mosquito Coast, but more accurately called the "Mosquito Reservation," is a strip of land about two hundred miles in length extending northward from the Rama River to the Rio Huesco, and backward from the sea about forty miles; the western boundary being an astronomical line along the meridian of longitude 84° 15′.

The so-called Mosquito Indians are by no means a homogeneous people. The interior river districts are inhabited by true Indians of various tribes and languages, agricultural in their habits—if such a thing as agriculture can be spoken of in this land of spontaneous vegetation and perennial summer. The coast

lands, which along their whole length are indented with a series of shallow lagoons separating them from the main sea, are inhabited by a mixed race in whose veins African and Indian blood are striving for the ascendency, with a dash of white blood infused

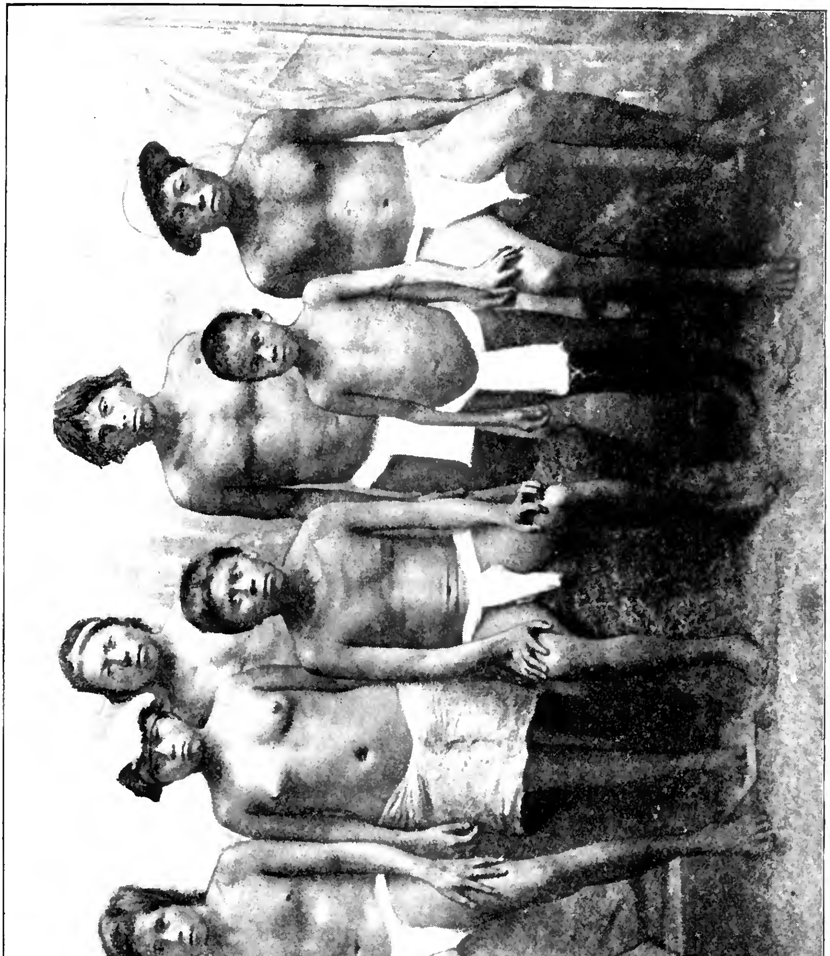

FIG. 2.—MOSQUITO INDIANS.

by buccaneers and Jamaica traders of the olden times. In the government of the community the people of the coast lands are the predominant element, the Indians farther in the interior being apathetic; nevertheless, the "chief," who is at the head of the government, is a full-blooded Indian. The official language,

and that generally spoken along the coast, is the English tongue. The Mosquito state is an autonomy under the sovereignty of Nicaragua, but to understand its unique position in the family of nations it would be necessary to give an outline of its more recent history. Such a sketch would scarcely prove of interest, and would far exceed the limits of this article.

Bluefields, the capital and only port of the Mosquito Reservation, gets its name from a famous old pirate of the past, called Bleevelt, the remains of whose stronghold—in an advanced state of decay—are still seen on a high promontory at the entrance of the harbor known as the "Bluff." The town proper lies about six miles from the sea, and is reached by crossing a large lagoon of such shallowness that only after much tugging, pushing, and pulling in small boats of the lightest draught is the passenger landed at the Government wharf. Seen from the lagoon, the town presents a pleasant picture. Seated upon comparatively high ground, the luscious green of the luxuriant vegetation in which it is framed runs quite down to the water's edge, while here and there a stately palm or cocoanut tree, its leaves nodding lazily in the almost imperceptible breeze, gives the landscape that calm, dreamy look so characteristic of tropical life. There is but one street in the town (King Street) leading up from the wharf. On this street are its few stores and trade shops. The rest of the settlement—covering an area of two square miles—is scattered about, wheresoever the householders willed it, without plan or reference to streets and lanes. At the time of my visit the town contained three horses and two carts or wagons, so it is evident that streets would be of less use for traffic than for the sake of symmetry, and Sambo idea of symmetry is an unknown quantity. The houses of Bluefields, with the exception of a few native "shacks," are built of lumber brought from the United States, and are similar in style of architecture to those found in small American villages. All buildings are erected on posts, and raised two or three feet above the ground, to avoid the wet and mud of the rainy season. The population, numbering about fifteen hundred, is composed principally of the descendants of Jamaica negroes, with a sprinkling of cross-breed Indians, Spaniards, and negroes; these are known as "Sambos."

Bluefields and Bananas.—Such as it is, Bluefields owes its prosperity chiefly to American enterprise and capital. The increasing demand in the States for bananas, and the proximity of the Mosquito country to New Orleans (the journey being only four days by steamer), induced some Americans of a speculative turn to explore the country, with a view to supplying the demand for the fruit. Their ventures were successful beyond expectation, the soil and climate being peculiarly adapted for banana grow-

ing, and to-day hundreds of beautiful plantations line the river banks for many miles, producing an average of forty thousand bunches per week, and Bluefields ships more of this fruit than any two other ports of the world. Among the signs of American influence is the appearance of the newspaper, a never-wanting adjunct to every well-regulated American embryo city. The paper, printed in English and issued weekly, is called the Bluefields Sentinel. It has quite a United States air about it, and is well pep-

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Fig. 3.—The Mosquito Chief and Executive Council: 1, Robert Henry Clarence, chief; 2, Hon. Charles Patterson, vice president and guardian; 3, Hon. J. W. Cuthbert, attorney general and secretary to the chief; 4, Mr. J. W. Cuthbert, Jr., government secretary; 5, Mr. George Haymond, councilman and headman; 6, Mr. Edward McCrea, councilman and headman.

pered with advertisements. The spiritual and educational welfare of the community has been taken in hand by the "Moravian Mission," whose little churches and schools are scattered all over the territory, and on Sunday the single street of Bluefields is alive with churchgoers, who seem to be coming and going to and from religious service all day long.

The government of the Mosquito Reservation consists of the hereditary chief and an Executive Council, the members of the

Executive Council being elected by a General Council, and the latter in turn being appointed by the chief from among the "head men" of the tribe and representative inhabitants of the various districts of the country. The present chief, his Excellency Robert Henry Clarence, who, as above stated, is a full-blooded Mosquito Indian, is a handsome, intelligent, and well-educated young man of twenty or thereabouts, with a magnificent head of glossy black hair. The other government officials are nearly all descendants of Jamaica negroes, and perform their duties with becoming gravity and ease. Hon. Charles Patterson, the vice president, whose features betray some admixture of European blood, is also the guardian of the chief during his minority. The law of the land, by the Mosquito Constitution, is declared to be the common and statutory law of England, so far as the same can be made applicable and not inconsistent with local customs and the enactments of the chief and Council. Many of the young men who desire educational advantages better than the local schools afford are sent to Jamaica or even to England. The land laws are very liberal. Each head of a family is permitted to take six hundred and forty acres on a ninety-nine years' lease, for which he pays an annual rental of three cents an acre to the Government, equal to about fifteen dollars American gold. He is expected to pay, besides, the cost of surveying his "section," but beyond this there is no tax of whatever kind imposed, no matter how valuable the improvements he may make. Altogether the Mosquito people have made a considerable advance toward civilized life. The missionaries have not succeeded entirely in uprooting the superstitious practices among the lowest walks of the population, and the *obeah* or *obeaism*, a system of necromancy, by which ill luck can be averted and injuries done to your enemies, has still a powerful hold. The periodic "big drunk" of former times, when whole villages used to engage in wild orgies, is no longer a popular institution, although it is possible that individuals do not disdain to indulge in a periodic spree. The Mosquitos proudly and justly boast that for many years they have lived and maintained their institutions in peace, whereas the sovereign Republic of Nicaragua is constantly riven and torn by revolutions and strife. The state of culture described is found, however, only in the "cities" and mission stations. Away from these and in the jungles the people are still pure savages.

The chapter on roads in Mosquito is as brief and of the same tenor as the chapter on snakes in Iceland. The only means of communication are the rivers and lagoons; beyond these all is dense, impenetrable forest and jungle, interspersed here and there in the more northerly portions by grassy plains called savannas. The principal article of commerce, besides the banana, is

mahogany. This huge timber is cut by the Indians of the interior, and hauled and shoved toward a river in the immediate vicinity, thence floated in rafts of two or three logs, or often as a single tree, down to the coast. Most of the banana plantations are on the Bluefields or Escondido River. The mouth of the river is about a mile north of Bluefields, and the plantations begin about twenty miles above this point and thence cover its banks in almost unbroken continuity for some distance beyond the city of Rama, sixty miles up stream. To facilitate the handling and shipping of the fruit, the plantations are always close to the banks, and vary in depth from fifty to two thousand yards.

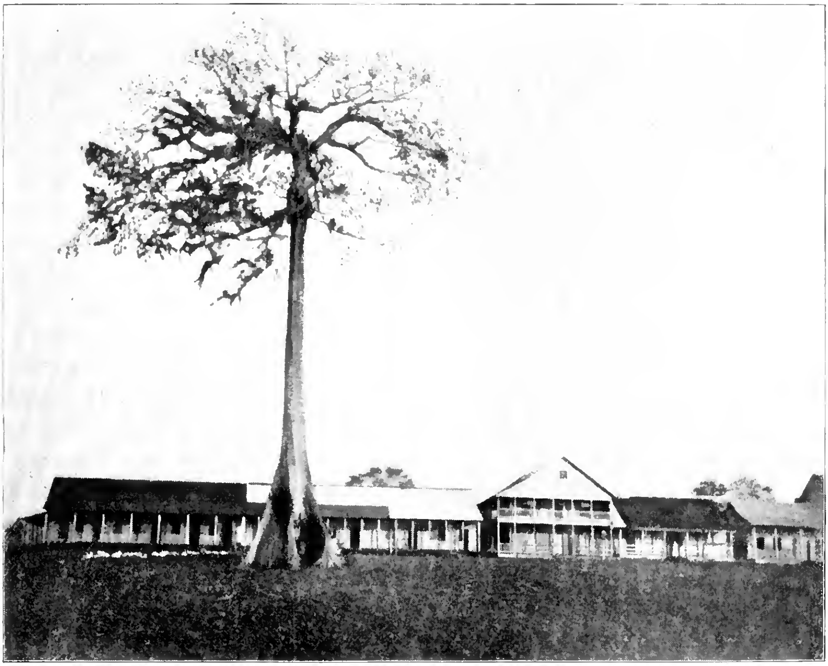

FIG. 4.—RAMA.

The steamer Hendy, an old Mississippi River boat, whose lightness of draught makes it well adapted for steaming about the shallow lagoons, plies regularly between Bluefields and Rama. Leaving the former place at seven o'clock in the morning, the trip to Rama begins by rounding a point of land called "Old Bank," a place which for a short time was the home of a small German colony. This settlement was abandoned after repeated trials and disasters; the unfortunate colonists being finally compelled to return to their native land, greatly reduced in number and weakened by disease, and after being harassed by the Spaniards and Indians. At this point the boat enters the Escondido

River. On each side the luxuriant and dense vegetation overhangs the water, a virgin jungle, whose somber shade the brightest sunlight fails to pierce. Flaming red herons rise and flutter or stand in comic solemnity watching us as we pass; gaudy macaws flash their flaring plumage among the leaves and utter hoarse cries as the boat wends its way; close to the shore, among the fallen trees and snags, huge alligators, innocent as yet of a knowledge of rifle ball or hunter, lift their ugly beaks in mute wonder at our intrusion upon their gloomy retreat. Indeed, a river trip is not necessary to see all this, a mile back of the town of Bluefields is the same impenetrable jungle. A meeting with a native tiger or jaguar is not an unusual occurrence in the outskirts, while in the rainy season, alligators from the lagoons are not too timid to carry off pigs and goats from the settlements.

After about twenty miles of steaming through those dark and gloomy channels, it is a pleasurable sensation to come upon the first clearing and see once more a sign of human activity. On every side are now evidences of thrift and industry. The picturesque houses of the planters, built of bamboo after the pattern of the native shacks and thatched with palm leaves, standing under the shade of tall cocoanut trees, make an ideal picture of tropic life. As the steamer lies to, for the purpose of landing supplies at many of the banana plantations, an excellent opportunity is given to study the manner of cultivation, if such it can be called. The only implement used by the cultivators is the machete, the universal native tool and weapon all in one; it is a rather long and broad knife, something between a broadsword and a cleaver in appearance. With the aid of this implement the native first clears the land of jungle and brush, each man being required to cut at least one "task" (twenty square yards) per day. Although this is only two or three hours' work, it is seldom that a native will do more than one task in a day. The natural inclination to work is of the faintest character. Nature has so bountifully provided all the necessaries of life that there would be no incentive to make money were it not for the passion for gambling, and a game of chance is the one thing the natives never seem too tired to engage in. The brush thus cleared is burned during the dry season and the ground is now ready for the young plants or shoots. These are "suckers" taken from older trees, and after planting them singly at distances of about eight feet apart, nothing further is required than occasionally to clear out the large weeds which will crop up between them. In two years the trees mature, reaching a height of ten to fifteen feet and bearing from one to three bunches each.

There is no such thing as a crop or a harvest as we understand the term with our northern possessions. Every day in the

year is seed time, every day is harvest time. Plants in various stages of maturity, plants in flower and in fruit and ready for the machete, stand side by side, and there is no winter to interrupt the process of vegetation. While the fruit is still quite green the plant is cut down, and the bunches being removed, these are carried to the river bank, where they are made into heaps and covered with the large leaves of the plant, so that the rain and sun may not unduly hasten the ripening. Only the largest bunches are reserved; the others are thrown into the river and left to drift away with the current.

The House in a Tree.—Rama is a town of about eight hundred inhabitants and, like Bluefields, is dependent chiefly upon the banana industry for its prosperity. It is situated right on the boundary line between the Mosquito Reservation and Nicaragua, and its population is a cross-breed of Spaniards and Indians. While at Rama I heard of a mysterious individual, a white man, who makes his home in a tree. Satisfying myself as to the substantial truth of the rumors, I determined to have a sight of the strange house of this eccentric person.

As the river steamer Hendy was to make a trip up the Rama River the following morning, passing the house in the tree, I accepted the invitation of Captain Tucker to accompany him. The captain was a typical Yankee, who had lived several years on the rivers of Nicaragua, and whose fund of information seemed inexhaustible. He kindly offered me his guidance to the house. After steaming several miles we came upon the "clearing" of Captain Henry Wilderson, for such is the name of the tree-dweller; and here, within a hundred yards of the river, stood this remarkable structure, its white painted sides and green window blinds making a striking object against the dark jungle surrounding it. Imagine a tall tree trunk nearly four feet in diameter and stripped of branches, rising fifty feet or more straight up into the air, and perched upon its summit this strange abode, looking for all the world like a huge lantern. It is said that Wilderson objects to visitors on curiosity bent, and a photographic camera pointed at the house would be quite apt to bring forth protests from the inmate, backed up if necessary by force and violence. Fortunately, on the day of our visit the captain was not at home, so our investigations were carried on without interruption. The tree upon which the house is built is a variety called the ebo; its wood is of great strength and hardness, and, as it would require days of work with an axe to fell it, Wilderson can feel quite safe on his lofty perch. The building is about twenty-five feet square and about the same in height. The tree runs completely through the center of the house to the roof. The first story is occupied by the kitchen; a sitting room and bedroom, with a small piazza facing the river, take

Fig. 5.—Banana Plantation.

up the next story; while the third story was intended for a bath-room and observatory. The whole is very solidly built of pine lumber. At each corner are heavy braces of timber reaching from the ground to the main floor, while four stout guy-ropes running from the house and fastened to adjacent trees assure the occupant additional safety against the strong winds which sometimes rage. To reach the house it is necessary to enter an elevator placed at the back of the tree. This is a simple contrivance, and consists of a small platform to which is attached a rope passing over a pulley in the kitchen. To pull one's self up requires but little exertion, as the weight of a person is balanced by a heavy counter-weight, which descends as the elevator rises by a hand-over-hand pull of the passenger, and in a few moments one is landed at the door opening into the structure. In descending, of course, the operation is reversed. The interior is furnished in very plain style and may be said to contain necessaries only; there is not the slightest attempt at ornament or decoration. The kitchen utensils are few and most of them of home manufacture; indeed, Nature in this country has supplied food in such form that cooking is a matter of secondary importance, and is not regarded as one of the serious affairs of the household. As rain falls almost continuously for nine months of the year, the house is not without its supply of water. This comes from the roof and is run into tanks conveniently placed within the house. Captain Wilderson, who is an old Louisiana planter, built his castle in a tree about three years ago, and it is said to have cost thirty-five hundred dollars. The oddity is the result of a theory which the captain has that germs of malarial fever are not as active at an elevation as they are near the ground. Wilderson is said to be hale and hearty, and in consequence thereof his theory has quite a respectable local standing.

Pearl City.—Travel about the rest of the reservation is not as easy as the trip to the banana district by the river steamer. The lagoons along the coast are not all connected by water, and to reach one from the other it is necessary to cut your way across the intervening land through the jungle. The swath thus cut with the machete may be said to answer a double purpose, as, besides enabling one to make progress, it leaves a trail by which one can return to the point of starting, thus diminishing the very serious consequences of becoming lost. As already stated, however, traveling is nearly all done by water. The inland water communication through the lagoons along the whole two hundred miles of coast is interrupted in only two places, and the rivers running into the interior are numerous. The native boats, which are large dugouts, called "pitpans," are hollowed out of trunks of the ceiba or silk-cotton tree. These trees when in bloom are a

novel spectacle. It is certainly something out of the common to see a gigantic tree, with a trunk five or six feet in diameter and eighty or ninety feet high, and sending out limbs as long and massive as an oak, yet bearing flowers like a rose bush. These

Fig. 6.—Gathering Bananas.

flowers are rich and variegated in color, but chiefly of a bright carnation. Viewed from beneath, they are scarcely visible; the fragrance is overpowering, and the ground is carpeted with their gay leaves and delicate petals. When seen from a little distance, the ceiba tree in bloom is one of the most splendid productions of Nature—a huge and brilliant bouquet, requiring a whole forest to supply the contrasting green. The wood of the ceiba is easily worked, and, moreover, is light and buoyant and not liable to split by exposure to the sun. It is these qualities which make it so valuable for building the different varieties of boats required on the coast. The boats are usually sent from the interior in a rough and partly finished condition, being simply dug out, the outside being left to be finished according to the taste and fancy of the future owner. The boats are commonly fifteen or twenty feet long and about two feet wide, but it is not unusual to meet them of much larger dimensions, sometimes reaching even the great length of one hundred feet. The ends rise gracefully from

the water, presenting an overhanging bow and stern exactly alike in shape. Although the natives paddle about in all kinds of seas and weather, to the novice the boats are most frail and cranky craft; the slightest demonstration is sufficient to careen them to the very verge of capsizing. When such an accident does happen, the natives, who are excellent swimmers, right the boat and, by dexterously shaking it from side to side, empty it of water, and then, jumping in, they will pursue their journey with the utmost complacency. They propel their canoes with large shovel-shaped paddles, which they work for hours without signs of fatigue.

Pearl Lagoon is the sheet of water immediately north of the lagoon of Bluefields. The two are separated by a neck of land known as "Haulover." Pearl City, the home of the chief, is situated on the banks of Pearl Lagoon, and is about thirty-five miles from Bluefields. Much of the journey is through dark, winding creeks, and nowhere on the trip, until the settlement at Pearl Lagoon is reached, can the slightest trace of civilization be seen.

Fig. 7.—Loading Bananas.

Pearl City is a far prettier place than Bluefields, and is built on a prairie or savanna of some six square miles in extent. I was cordially received by Robert Henry Clarence, the Mosquito chief, who placed at my disposal one of his three horses, and I had

the pleasure of the company of his Excellency on a canter over the plain. The little chief proved a furious rider, and spurred his horse to a breakneck gait, so that I had the greatest difficulty to keep up with him. Jumping from his horse, he disappeared for a moment in the brush, and presently returned with some luscious pineapples, which he peeled and, cutting lengthwise, offered me to eat. Among the institutions at Pearl City is the brass band of fourteen pieces. The band is under the leadership of Mr. J. W. Cuthbert, Jr., the Secretary of the Executive Council of the Mosquito nation. The Sambos performed for our edification and to their own satisfaction for at least two hours. Among the tunes were some which I recognized as having done long service on our variety stage.

The genuine Mosquitos, although they number over six thousand, are rarely met with at the coast settlements. They do not care to observe the restrictions put upon them by the local authorities in clothing themselves. Scantiness of dress is characteristic of a true Mosquito Indian, and in the interior of the country they can be observed in all their natural simplicity of costume. It must be admitted that for this hot, moist climate this is not an unreasonable state of affairs. I was fortunate in securing pictures of a number of groups of natives, both of the true Mosquito and of the Sambo variety, and some of these, with a picture of a native "shack" or bamboo house, are shown in the illustrations. Besides the banana and mahogany, the Mosquito country has other valuable resources. In its northern portion the country has extensive savannas covered with luxuriant grass the whole year round, affording admirable opportunities for cattle-raising. This business is yet in its infancy, but promises to assume respectable proportions. Cotton blooms wild and will bear through the entire year; sugar cane will produce a crop every seven months; rice, every four months; and oranges, lemons, limes, pineapples, and a host of other fruit grow wild. The upper runs of the northern rivers and creeks have gold-bearing sand, and it is not impossible that some day the "Reserve" will take rank as a gold-producing country.

The "amber and jade" mines of Upper Burma have been visited by Dr. Noettling, who has reported upon them to the Geological Survey of India. The "amber" is a fossil resin corresponding with that called burmite, fluorescent, looking like solidified kerosene oil, and darker and harder than ordinary amber. The "jade" is jadeite, worked in pit and quarry mines for forty miles along the bank of the Uru River and on the top of a plateau at Tammaw. The industry is a thriving one, employing five hundred men, and promises well for future more systematic and skilled development. White is the commonest color; green is rare; and some of the bowlders are red.

WEISMANN'S CONCESSIONS.

By LESTER F. WARD.

NEARLY three years ago, and before the appearance of the second volume of Weismann's Essays,* in a Critique of Weismann,† based entirely on statements contained in the first volume, I intimated that in my judgment he had already admitted enough to invalidate his doctrine of the non-transmissibility of acquired characters where these are of a functional nature. After showing from his own language that, according to his theory, no variation would be possible later than the Protozoan stage of development, which was a *reductio ad absurdum*, I proceeded to point out that, apparently from a sense of this position, he had actually admitted the possibility that external influences may affect the germ. One of the passages embodying such an admission is the following:

"I believe, however, that they [hereditary variations] can be referred to the various external influences to which the germ is exposed before the commencement of embryonic development. Hence we may fairly attribute to the adult organism influences which determine the phyletic development of its descendants. For the germ cells are contained in the organism, and the external influences which affect them are intimately connected with the state of the organism in which they lie hid. If it be well nourished, the germ cells will have abundant nutriment; and, conversely, if it be weak and sickly, the germ cells will be arrested in their growth. It is even possible that the effects of these influences may be more specialized; that is to say, they may act only upon certain parts of the germ cells." ‡

In the same essay, speaking of the influence of climate, he also uses language that has a decidedly Lamarckian sound:

"It is difficult to say whether the changed climate may not have first changed the germ, and if this were the case the accumulation of effects through the action of heredity would present no difficulty." #

Upon this, my comment was:

"I can not see why this is not conceding the whole issue. Of

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* Essays upon Heredity and Kindred Biological Problems. By Dr. August Weismann. Authorized Translation. Oxford: At the Clarendon Press. Vol. i, 1889; vol. ii, 1892.

† Neo Darwinism and Neo-Lamarckism. Annual Address of the President of the Biological Society of Washington, delivered January 24, 1891. Proceedings, vol. vi, Washington, 1891, pp. 45–50.

‡ Essays, vol. i, pp. 103–104.

Ibid., p. 98.

course, all modifications must first affect the germ, otherwise there could be no hereditary transmission. The only question is: Can the climate or the environment impress changes upon the germ? If yes, the Neo-Lamarckian asks no more. All that he contends for is conceded." *

In his later work on the Germ-Plasm,† Prof. Weismann says that I am in error if I suppose that "the proof that climatic influences are capable of modifying the germ-plasm contains all that is required by the Neo-Lamarckian school." It is true that climatic influences in the restricted sense are not the only ones that Neo-Lamarckians suppose to act directly upon the germ. They maintain that *functional* variations are heritable to a greater or less degree, and make the chief distinction between these and *accidental* variations, such as mutilations and other injuries. The principal stress has hitherto been and still continues to be laid, by both Prof. Weismann and his followers, upon the latter class, which is therefore a waste of words and a mere show of argument calculated to deceive those who have little acquaintance with the subject. But when it comes to modifications of form which are brought about by the efforts and struggles of the creature to obtain its sustenance or accomplish desired ends, the case is wholly different. Such modifications are necessarily complex and involve a harmonious adjustment of all the parts that are brought into exercise, which, when transmitted, secures the complete and systematic variation which species are believed to undergo. Climatic influences are among the most important ones against which the creature thus reacts, but the entire environment may be regarded as constantly impinging, so as to bring about perpetual modifications.

In the second volume of his Essays there are further concessions in this same general direction. In his reply to Prof. Vines, he is compelled to admit that variation may take place in different forms of asexual reproduction, which is a practical abandonment of his theory of the continuity—i. e., of the unalterable nature—of the germ-plasm. He is apparently willing to "concede that some amount of individual variability can be called forth by direct influences on the germ-plasm." ‡ Surely a discussion as to the "amount" of such variation is a radically different thing from a discussion as to whether it can take place at all. The principle at issue is shifted when such an admission is made.

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* Neo-Darwinism, etc., p. 58.

† The Germ-Plasm: A Theory of Heredity. By August Weismann. Translated by W. Newton Parker and Harriet Rönnfeldt. New York: Charles Scribner's Sons, 1893. Contemporary Science Series. See p. 408.

‡ Essays, vol. ii, p. 95.

But this was only a beginning of the almost complete retreat that he has now made in his last work on the Germ-Plasm. As before, it seems to have been the phenomena which the vegetable kingdom presents that most obstinately refuse to adapt themselves to the mechanical theory of heredity of which he is the author. Before these facts his fundamental distinction between the blastogenic and the somatogenic idioplasm breaks down completely, and here at least he is "compelled to assume that *most,* if not all, of the *cells contain all the primary constituents of the species in a latent condition.*" * After carefully considering such cases as those of Bryophyllum and Begonia, almost any part of which may be made to grow if properly situated, he admits that such observations "apparently prove that 'every small fragment of the members of a plant contains the elements from which the whole complex body can be built up, when this fragment is isolated under suitable external conditions.'" †

Before passing to the major admissions of Weismann it may be well to mention a few of the "doubtful phenomena of heredity" which, in case they really occur, form such a stumbling block to his system. On this side of the water one is amused at the statement that "blue grains occasionally occur among the yellow ones in cobs of the yellow-grained maize (*Zea*) after fertilization with the pollen of a blue-grained species." ‡ There is probably only one "species" of Indian corn, but the cultivated varieties are endless, and every farmer's boy knows that it is of the greatest importance to keep these apart, so that the ears will "fill" with the same kind of kernels. Few American farmers would hesitate to stake their farms on the much more than "occasional" occurrence of different kinds of kernels on the same cob in a field where different varieties are planted together.

As regards the numerous cases of the alleged transmission of characters derived from one sire to the offspring of a subsequent sire, though disposed to discredit the evidence, he nevertheless admits their possibility to a limited extent. For he says of them: "We may, however, at any rate suppose that this so-called 'infection,' if not altogether deceptive, only occurs in rare instances, and by no means regularly, or at most only in some cases." #

Here we have again, as in the general case above considered, a characteristic Weismannian argument, shifting the point from the qualitative to the quantitative, from the principle to the degree, which reminds one very forcibly of Jack Easy's wet nurse

* The Germ-Plasm, p. 206. The Italics are his in this and all subsequent passages.

† Ibid., p. 212. The words quoted by Prof. Weismann appear to be taken from De Vries.

‡ Ibid., p. 383.

Ibid., p. 385.

Sarah, who sought to excuse the illegitimacy of her child by the plea that "it was a very little one." In his reply to Mr. Herbert Spencer's articles * he has made matters worse by explaining it on the supposition that "spermatozoa occasionally reach the ovary, and there enter into some of the immature eggs. Amphimixis can not proceed, as the germ-plasm of the egg is not ripe, but the nucleus of the sperm cell continues to live in certain circumstances, and so remains till the time of a subsequent *coitus* with another mate." †

It is obvious that in such a case the "subsequent *coitus*" need have nothing to do with the matter; whenever the egg was ripe there would be nothing to prevent amphimixis taking place, followed by all the stages of ontogeny, and we should have a case of parthenogenesis in the mammalia. If this were possible in the human race it would create something of a ripple in the social world.

Prof. Weismann does not deny that certain diseases, especially germ diseases, are hereditary and directly transmissible in the first instance, and he admits that this has "definitely been proved to occur in the case of syphilis. The father, as well as the mother, is capable of transmitting this disease to the embryo, and the only possible explanation of this fact is, therefore, that the specific bacteria of syphilis can be transmitted by the spermatozoön." ‡ But he will not admit that this constitutes a case of the transmission of acquired characters, undertakes to connect it with the adaptation of the parasite to the host, and concludes:

"It will, I think, at any rate be conceded that a 'constitutional' disease can not be taken as a proof that the processes of heredity are therein concerned until we can determine whether we are actually dealing with heredity—i. e., the transmission of a constitution—and not only with a transference of microbes." #

This all seems very absurd to the average reader, and conveys the impression that the scientific discussion of these questions has, after all, no interest for the public, and only amounts to a useless hair-splitting on the part of the doctors. For what matters it to the consumptive whether his case is one of "the transmission of a constitution" or "the transference of microbes"? Mr. Spencer, in the articles above referred to, has sufficiently characterized the reasoning which allows a microscopically visible microbe to pene-

* The Inadequacy of "Natural Selection." Contemporary Review for February, March, and May, 1893; reprint, London, Williams & Norgate; New York, D. Appleton & Co., 1893, p. 69.

† The All-sufficiency of Natural Selection. A Reply to Herbert Spencer. Contemporary Review for September and October, 1893, p. 609.

‡ The Germ-Plasm, p. 388.

Ibid., p. 391.

trate tissues through which even biophors can not pass; and Prof. Weismann, in showing that the latter must break out of jail, should also explain how the former are able to break into jail. Taking all these things into account, I am constrained to repeat a former remark, that "if the term 'acquired' is to be any further refined away, then discussion is useless, for it is not a mere dispute about a word that interests us, but the fundamental question whether external conditions do or do not permanently and progressively influence the development of organic beings." *

Reverting, then, to the main question as to the influence of external conditions on the germ, I would remind the reader that in his essay on amphimixis, originally published in 1891, Prof. Weismann held that "*a belief in the inheritance of acquired characters by the highly differentiated Protozoa, as well as by Metazoa, must be opposed*," and imagined that "*the phyletic modifications of Protozoa arise from the germ-plasm, that is from the idioplasm of the nucleus*"; † and he further says:

"My earlier views on unicellular organisms as the source of individual differences, in the sense that each change called forth in them by external influences, or by use and disuse, was supposed to be hereditary, must therefore be dismissed to some stage less distant from the origin of life." ‡

He then ascribed all variations above this early stage to amphimixis and sexual reproduction. In the new work he indeed reiterates this view, and says that these processes furnish "an inexhaustible supply of fresh *combinations* of individual variations which are indispensable to the process of selection." # But he now introduces the following important qualification:

"Although the process of amphimixis is an essential condition for the further development of the species, and for its adaptation to new conditions of existence among the higher and more complicated organisms, *it is not the primary cause of hereditary variation*." ‖

He then proceeds to explain the change that has taken place in his mind, obviously while writing this book, admits that he had overestimated the power of sexual reproduction to modify species, and shows that though the general result might be changed there could be no variation in the determinants themselves, "which alone could gradually lead to a transformation of the species." Not only is amphimixis incapable of modifying the determinants, but it is also, and for the same reason, incapable of increasing the number of kinds, yet on his general theory these

* Neo-Darwinism and Neo-Lamarckism, etc., p. 59.

† Essays, vol. ii, p. 192.

‡ Ibid., p. 193.

The Germ-Plasm, p. 413.

‖ Ibid., p. 414.

must be enormously increased with the development of every species. A new principle must therefore be found to explain the observed fact. Strangely enough, he finds this principle to be none other than the Lamarckian law of the effect of external conditions in modifying the hereditary elements!

"Amphimixis alone could never produce a multiplication of the determinants. *The cause of hereditary variation must lie deeper than this; it must be due to the direct effect of external influences on the biophors and determinants.*" *

It is easy to see that this is a complete abandonment of his fundamental doctrine of the immutability of the germ-plasm, and here again he shifts the point of the argument to the quantitative, and would have us believe that it was the same thing to say that it possesses "great power of remaining constant." But he adds:

"We can none the less avoid assuming that *the elements of the germ-plasm*—i. e., the biophors and determinants—*are subject to continual changes of composition* during their almost uninterrupted growth, and that *these very minute fluctuations, which are imperceptible to us, are the primary cause of the greater deviations in the determinants, which we finally observe in the form of individual variations.*" †

These variations that take place in the hereditary elements he ascribes to "the impossibility of a complete uniformity as regards nutrition existing during growth," or to "the modifying influence of nutrition." The following passage is as complete an admission of the Lamarckian principle as any one need wish, while at the same time it illustrates over again his characteristic tendency to evade the issue by maintaining that its influence is small compared to that of some other principle:

"Even though it can no longer be doubted that climatic and other external influences are capable of producing permanent variations in a species, owing to the fact that, after acting uniformly for a long period, they cause the first slight modifications of certain determinants to increase, and gradually affect the less changeable variants of the determinants also, the countless majority of modifications is not due to this cause, but to the processes of selection." ‡

In this passage there is a curious psychological implication in the expresssion "no longer," which obviously refers to the changes in his own mind, that are by him projected to the world at large, which, as a matter of fact, has from the first intuitively arrived at the conclusion which has cost him such a great cycle of elaborate reasoning. This new theory of his as to the origin of variations is summed up in the following paragraph:

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* The Germ-Plasm, p. 415. † Ibid., p. 417. ‡ Ibid., p. 422.

"*The origin of a variation* is equally independent of selection and of amphimixis, and is due to the constant recurrence of slight inequalities of nutrition in the germ-plasm which affect every determinant in one way or another, and differ even in the same germ-plasm—not only in different individuals but also in different regions. These variations are at first infinitesimal, but may accumulate; and, in fact, they must do so when the modified conditions of nutrition which gave rise to them have lasted for several generations. In this way deviations may occur in the structure of single determinants or of groups of them—never, perhaps, in all ids at once, but at any rate in several or even many of them. A doubling of certain determinants of the germ-plasm may originate in the same way. The process of amphimixis has an important share in the accumulation of these modified determinants, for it may raise the minority previously existing in the two parents to a majority by combining their halved germ-plasms. Then, and then only, does selection begin to take place." *

After all this it is certainly surprising that he should still cling to his former declaration that acquired characters are not transmissible. After abandoning all his premises he still adheres to his conclusion. Dr. J. G. Romanes, who has been one of his most liberal critics, after characterizing the latter part of the Germ-Plasm as "a right-about-face manœuvre," says that his first impulse "was to cancel all the criticisms which I had written of the Weismannian theory," † and it really seems as though it were time to drop this prolonged discussion. Its further continuance must certainly be chargeable to his own course as pursued in Chapter XIII of his Germ-Plasm, and in his reply to Mr. Spencer in the face of these concessions. It is somewhat difficult to understand how he is able to reconcile these apparently conflicting views. That he does not limit the influence of external conditions to the germ-plasm proper, or fertilized germ cell, is apparent from his cheerful acceptance of Nägeli's "opinion that all variations are slowly prepared in the idioplasm in the course of generations before they become apparent," and we must suppose him to admit that it is the hereditary units themselves that are undergoing these transformations. In my address before the Biological Society I had referred to this in the following language:

"You will understand that I am speaking of variations which take place in the germ cells and sperm cells of parental organisms before they blend in the fertilized ovum. Most of Weismann's argument is directed to show that the fertilized ovum itself can not be affected by any transforming influence acting upon the

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* The Germ-Plasm, p. 431.

† The Open Court, vol. vii. Chicago, September 14, 1893. Supplement, p. iii.

mother during the growth of the embryo. This may be true, but it is unimportant. The time required to develop the embryo is too short for the environment to produce any material change however strong the tendency might be at the time in the direction of such change. It is chiefly the uncombined sexual elements which are admitted by all to be undergoing specific transformation." *

This is the main issue, and if admitted, the Neo-Lamarckian asks no more. How then does Weismann evade this issue? He says:

"It is self-evident from the theory of heredity here propounded, that only those characters are transmissible which have been controlled—i. e., produced—by determinants of the germ, and that consequently only those variations are hereditary which result from the modification of several or many determinants in the germ-plasm, and not those which have arisen subsequently in consequence of some influence exerted upon the cells of the body. In other words, it follows from this theory that *somatogenic or acquired characters can not be transmitted.*" †

From these and other statements we are obliged to infer that while he admits the power of external influences to affect the somatic cells at all points where they impinge, adapting the organs of the body to the environment, and also admits that inequalities of nutrition (which at bottom are the same thing) modify the germ cells, he denies that these two facts have any connection with each other. Obvious as it is that the species becomes modified to suit the changing environment just as does the individual, he attributes the former wholly to natural selection and the latter wholly to direct adaptation. All, therefore, that is gained by this latter process is necessarily lost, and we have a strong indictment against Nature, "who," he says, "always manages with economy." ‡ It seems far more logical to argue from the economy of Nature and the parallelism of these two processes for a causal connection between them.

But it must not be forgotten that he now makes natural selection itself entirely dependent upon "inequalities of nutrition" in the germ-plasm as its universal antecedent. Is this then so widely different from the direct adaptation that takes place in the somatic cells? Let us see how narrow the distinction grows with careful analysis. He admits that alcohol affects the germ and sperm cells by debilitating them and makes weakly children. He would admit the same of any deleterious drug. He would not deny that any disease that debilitates the parents

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* Neo-Darwinism and Neo-Lamarckism, etc., p. 49.

† Germ-Plasm, p. 462.

‡ Ibid., p. 63.

would have a similar effect. These agencies may be regarded as the opposites of nutrition—i. e., as constituting part of the "inequalities of nutrition" that affect the germ and cause it to vary. Variations in the germ-plasm are necessarily quantitative, more or less, according as nutrition is abundant or deficient, and all qualitative differences must be due to the external influences affecting certain constituents more strongly than the rest. How, then, does this differ from pure Lamarckism?

When we say that an organ is strengthened by use, there is obviously an ellipsis. What we mean is that exercise increases nutrition and nutrition strengthens the organ. We may be even more explicit and say that exercise causes increased circulation to the part exercised, causing more tissue to be deposited, thus enlarging and strengthening the organ. Lamarck, of course, understood all this, but did not think it necessary to explain these elementary principles. It is the same with the influence of climate and of the environment in general. All these agencies produce variation by affecting nutrition. If defective nutrition can affect the germ-plasm, why can not abundant nutrition affect it? How does the germ get its nutrition except in the same way that all the other cells of the body get theirs, through the food supply? Is the germ "immortal" in the sense that, like spirit, it can subsist indefinitely upon nothing? If it depends upon sustenance from the body, it must receive its nutrition from the body, and the quantity and quality of that nutrition will vary as those of the body vary. That they do vary he admits, and makes this the very *fons et origo* of hereditary variation.

But it does not seem possible to Prof. Weismann that a specific variation of some organ or part of the body can influence the reproductive products in precisely the same way so as to perpetuate that variation in the progeny. That we can not understand this may be freely admitted. It is the essence of the mystery of heredity. We know that like produces like. If we abandon that principle, there will be no stopping short of the opposite one, that like produces unlike. It is the same in principle to say that horses may produce cattle as to say that robust horses may produce feeble ones, although the robust ones may have acquired their robustness, not formerly possessed, through proper food, care, and treatment. And there is still no difference in the principle if, instead of robustness, the character be some specific one, such as a "racking" gait, which might be acquired during the life of a single individual. Such qualities are often transmitted. So, too, are the colors of flowers, which can be changed by adding certain ingredients to the soil, as are also certain artificially enforced habits in plants, such as are engendered by "layering," etc. But these are characters only feebly impressed and can not be expected

to persist unless carefully aided by artificial selection, yet they *must* have commenced as acquired characters. Well-broken horses and well-trained dogs transmit these qualities to their offspring, and all domestication and cultivation of animals and plants, all changes wrought in them by man, must have been first acquired to some degree, and then, by intelligent selection, the degree can easily be increased. Like produces like, and if we can not explain why, it is because we have not yet solved the problem of heredity. The elaborate theory offered by Prof. Weismann in his Germ-Plasm, plausible as it sometimes seems, true as it doubtless is in many of its details, utterly fails to solve this problem. It is altogether too rigid, too mechanical, to explain such subtle phenomena. Nature is more flexible, more self-adjusting, more delicate than his system contemplates, and is constantly doing just those things which he insists can not be done.

I trust that it has been sufficiently shown, chiefly from his own words, that in elaborating this complicated theory Prof. Weismann, guided, as he always seems to be, by the highest regard for truth, has, greatly to his credit, conceded all the essential points in the long controversy as to the inheritance of acquired characters. The discussion may therefore be regarded as narrowed down, not so much to the relative importance of the direct and indirect factors, as to the degree to which in any given case the one or the other has operated in determining the observed result.

THE CINCINNATI ICE DAM.

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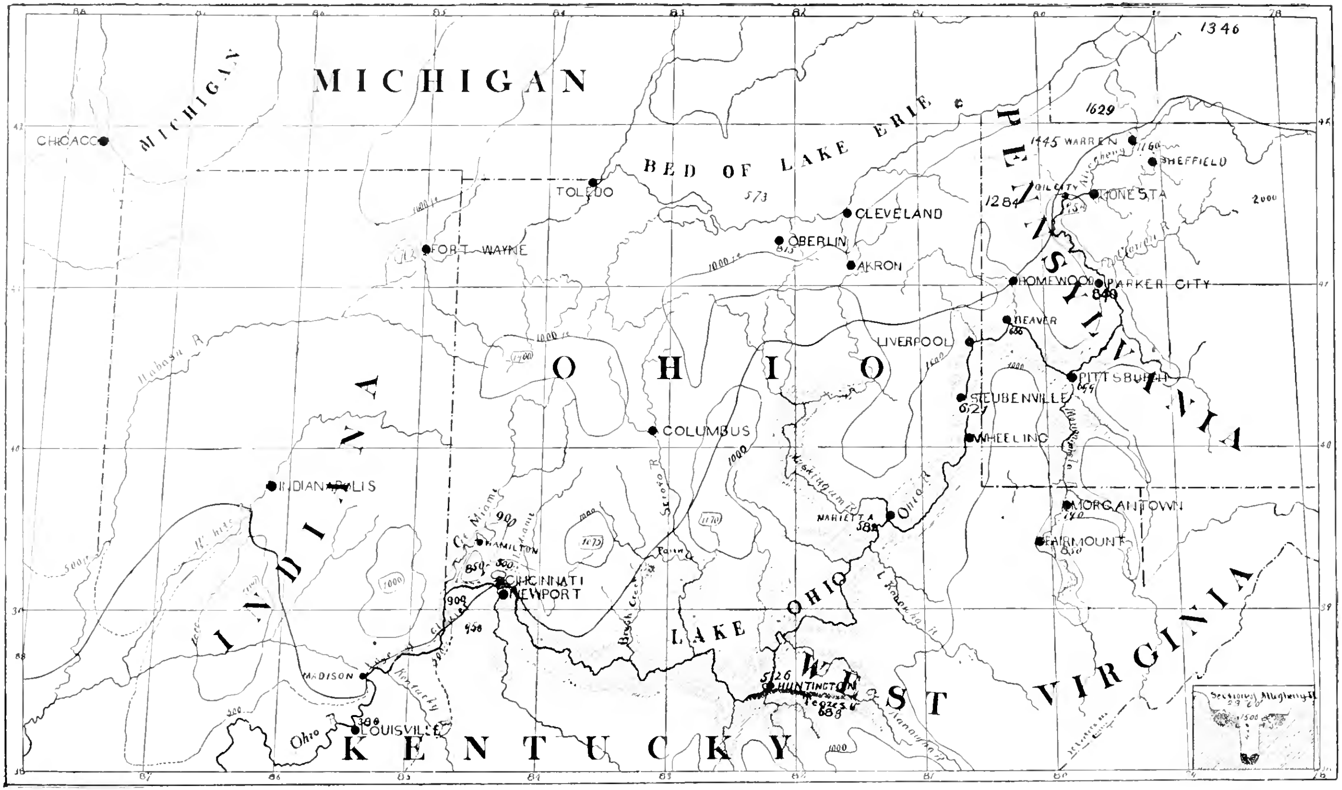
IN many respects the Ohio is one of the most remarkable rivers in the world. Its drainage basin comprises about two hundred thousand square miles on the northwestern slope of the Alleghany Mountains. Its eastern tributaries rise at an elevation of something over two thousand feet above the sea, and hence are so situated as to carry the rainfall and the melting snows with great rapidity into the main channel, which at Pittsburg is seven hundred feet above the sea, and at Cairo, where it unites with the Mississippi, about three hundred feet; the descent from Pittsburg to Cairo being about four hundred feet in a distance, as the river runs, of nearly a thousand miles.

The whole course of the river is through sedimentary rocks, which, though of Palæozoic age, have been but slightly disturbed. The elevation of the region has been so continental in its proportions that the rocks have retained to a great degree their original

horizontal position. Through these comparatively horizontal strata the Ohio River has worn a gorge of remarkable uniformity, and several hundred feet in depth. Even to the ordinary observer it is clear that this trough is one of erosion; for the strata of rock upon one side of the river match those upon the other as precisely as do the two ends of a board which has been sawed apart. The seams of sandstone, coal, and lime rock upon one side correspond to similar seams upon the other; while the river does not pursue a straight course, but follows, throughout, a very tortuous channel, such as is begun by the meandering of a stream over a nearly level surface.

The width of this rocky gorge is from a quarter of a mile, where the rocks are peculiarly hard, to a mile or over, where they are more easily disintegrated. For the most part, also, the tributaries occupy corresponding gorges, with a width contracted to the proportion of the individual drainage basins. At the junction of the main stream with the tributaries there is usually an enlargement of the gorge such as would naturally follow from the combination of erosive forces which there occurs. These features of the trough of the Ohio and its tributaries give character to the scenery throughout its course. Nowhere from the decks of the steamer does one get an extended view on either side. Everywhere the vision is circumscribed by the hills, more or less precipitous, which rise close at hand upon both the right and the left; while the windings of the channel are such that no very distant views are obtained either before or behind. The railroads which connect the cities in the valley are compelled either to hug the side of the gorge between the river and the precipitous ledges, or to strike up some one of the tributaries, and then, after crossing the country for a while, follow down another to the level of the main stream. The land a little back from the trough of the river is very broken and hilly, since all the affluents of any size have eroded channels for themselves down to the depth of the principal gorge.

Above Louisville, Ky., the large cities upon the Ohio strikingly reveal the limitations imposed upon them by the character of the river valley. Having begun as a cluster of houses upon the river's bank, they have gradually spread back upon it, until reaching the base of the rocky precipices. With the rapid growth both of population and of improvements in later years, Cincinnati and Pittsburg have literally overflowed their banks and risen to the summit of the hills on either side, the inhabitants being transported from their places of business to their residences by long inclines up which the street cars are drawn at a steep angle to a height of from three to five hundred feet, from which positions extended views are given in every direction over the



Map 1, showing the 500-foot and the 1,000-foot contours of the Ohio Valley; also the boundary of direct glacial action and the approximate limits of the slack water produced by the Cincinnati ice dam. The figures give the elevation above the sea. Those along the river refer to the low-water mark. In the lower right-hand corner is a typical section of the Alleghany, showing the rock channel and the high-level terraces.

broken surface whose summits represent the once comparatively level area. At Parker City, Pa., an elevator was once used to lift foot travelers from the lower terrace to the upper terrace, two hundred feet above.

Although flowing in so deep a trough, the present Ohio River is considerably elevated above the ancient bottom. This is owing to the fact that during the Glacial period such an excessive amount of gravel was brought down from the Alleghany River and other northern tributaries that the old channel was silted up to a considerable depth. At Cincinnati there is more than one hundred feet of gravel between the present river bottom and the rock bottom. Below the mouths of the most important northern tributaries the accumulations were much greater than this. At Cincinnati the channel was choked with gravel from the Little Miami to a height of one hundred and twenty feet above the present river. Subsequently this was partly eroded away, leaving the one-hundred-and-twenty-foot gravel terrace which is now occupied by Fourth Street.

It is fortunate for civilization that there are left along the trough of the Ohio numerous remnants of this high-level glacial terrace; otherwise the cities would be even more subject to damage from floods than they are now; for the Ohio River is subject to greater fluctuations of level than almost any other stream in the world. During the flood of 1884 the water rose at Cincinnati seventy-one feet, submerging the railroad stations and much of the lower part of the city, but leaving that portion which was upon the glacial terrace fifty feet above water. The cities which were not favored with so marked a gravel terrace, or had not taken advantage of their opportunities, were for many days turned into miniature Venices, the lower stories of the houses being generally submerged by the muddy torrent, and boats being able to pass freely through all the streets.

The cause of these enormous floods along the Ohio is readily perceived; for, as already remarked, the slope of the streams rising along the summit of the Alleghany Mountains and flowing into the Ohio is so rapid that the water from the rains and melting snows finds its way into the main trough of the river in an incredibly short time, while the trough is so narrow in places, especially just below Cincinnati, as greatly to impede the progress of the current. Two or three inches of rainfall over two hundred thousand square miles provides an enormous quantity of water, which, upon being suddenly transferred to the river channel, turns a stream which can sometimes be forded in dry weather into a steadily advancing column of water one thousand miles long and from fifty to seventy-five feet deep. It is interesting to watch from the weather bulletins the progress of the waves that move down the

Ohio upon the unusual rise of any of its upper tributaries. At Pittsburg thousands of coal barges collect during low water to take advantage of these waves of translation, and move forward upon them with their valuable freight like a vast army to supply the great cities of the Mississippi Valley with fuel. But, as with

Fig. 1.—Jasper Conglomerate Bowlder, Three Feet in Diameter, from North of Lake Huron. Found near Union, Boone County, Ky. (See Map II.) From photograph by the author, reproduced in The Ice Age of North America, p. 328.

everything else, the best gifts of Nature are those which come in moderation. Enough is better than more. Excessive floods interfere with navigation as effectually as does a lack of water.

With these facts in mind, while surveying, in the year 1882, the glacial boundary across the Mississippi Valley, I reached Cincinnati, having traced the border line to the river twenty-five or thirty miles above the city. Upon crossing to the general level of the hills in Kentucky, I found various indubitable evidences that the ice had extended across the trough of the Ohio, and left its marks several miles south of the river over the northern part of Boone County, and up to an elevation of more than five hundred feet above low-water mark. This was along the watershed between the Licking and Ohio Rivers, which was continuous at this height to the central part of Kentucky. Among other evidences one of the most conspicuous was a bowlder of jasper conglomerate, three feet in diameter, found near Union, in Boone County, which was subsequently transported to Chicago as a part of the Ohio glacial exhibit at the Columbian Exposition. Its right to have a place in an Ohio exhibit was due partly to the fact that it was discovered by an Ohio man, but chiefly from the fact that, at

the snail's pace at which a glacier moves, this bowlder must have been in the territory of Ohio for an enormous period of time, long enough for even a bowlder to become naturalized. If, however, the Canadians should claim it as a fugitive from justice, they would have a prior right, for the ledges from which it was derived are near Thessalon, in Ontario, north of Lake Huron. In searching for bowlders in southern Ohio, I was accustomed to hear them referred to as "niggerheads." In the progress of discovery it was found that the numerous articles of that description which in recent times Kentucky had furnished to Canada were in payment of a debt under which the Dominion had placed the southern commonwealth long ages before.

It is important to note that my discovery of Canadian bowlders on the hills of Kentucky was not the first which had been made there. As far back as 1845 Prof. Locke had noted the post-glacial conglomerate called Split Rock, below Woolpert's Creek, opposite

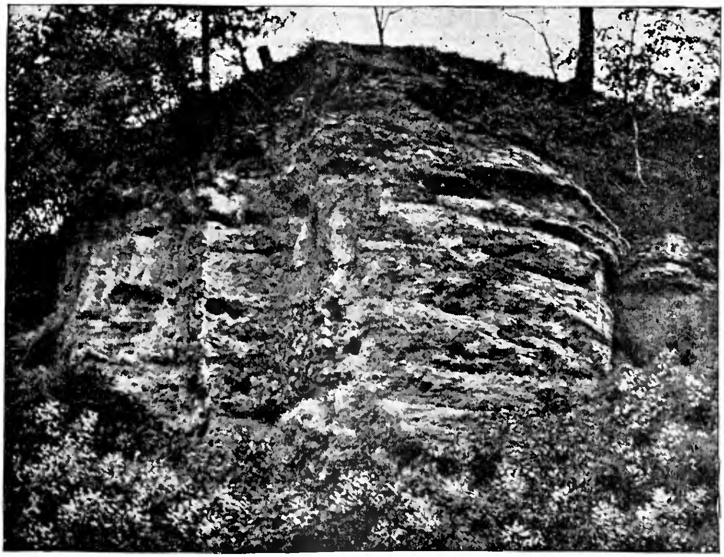


FIG. 2.—SPLIT ROCK, NEAR MOUTH OF WOOLPERT'S CREEK, KY. This is part of an extensive deposit of bowlders and gravel with some Canadian pebbles, all cemented together by infiltrated carbonate of lime. From photograph by the author, reproduced in The Ice Age of North America, p. 345.

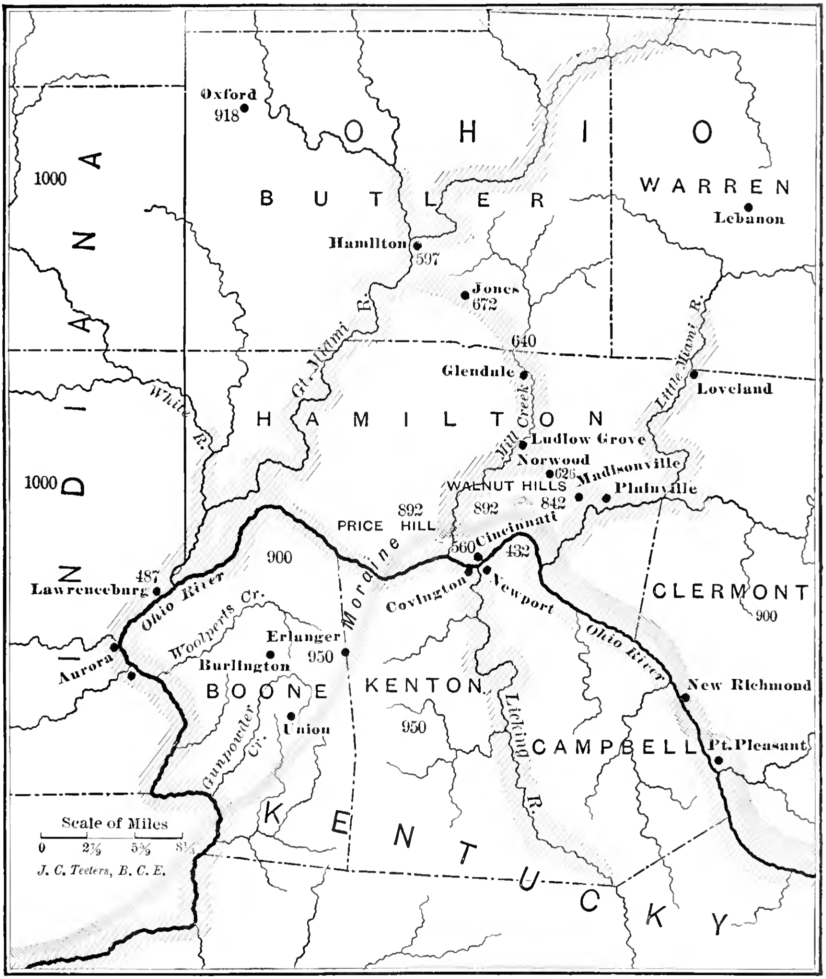
Aurora, Ind., but had regarded this as the remnants of local strata which had been nearly worn away. In 1872 also, Mr. Robert B. Warder had suggested that this was possibly a terminal moraine. Still later Dr. Sutton, in 1876, and Prof. Cox, in 1878, had noted similar deposits near the summit of the Kentucky hills, on Middle Creek opposite Aurora, and had attributed them correctly to glacial action during the maximum stage of the great

Ice period. But because of the imperfect knowledge of the glacial geology of the valley possessed at that time, these discoveries attracted little attention. Various causes, however, conspired to give a somewhat extraordinary notoriety to the facts as they were presented at the meeting of the American Association for the Advancement of Science at Minneapolis in 1883. At that time a systematic exploration of the glacial boundary had been conducted from the Atlantic Ocean to Cincinnati, showing that the Ohio River lay for the most part considerably south of the farthest extension of the ice. Also attention was then first called to the full extent to which the ice had crossed the river in that vicinity. For a distance of nearly one hundred miles it was now demonstrated that the ice came down to the north margin of the trough of the river, and for much of that distance crossed it and mounted the hills upon the opposite side, reaching at one point fully ten miles upon the high land beyond the river. This could not well help suggesting the formation of an ice dam at Cincinnati which would set the water back up the Ohio and its tributaries to the level of the watershed between the Licking and the Ohio, thus forming a narrow and tortuous lake several hundred miles long, which would be five hundred feet deep above Cincinnati and two hundred and fifty feet deep at Pittsburg. (See Map I.)

Finally, some of the geologists who had been engaged upon the survey of western Pennsylvania at once came forward and affirmed that such an obstruction as this supposed at Cincinnati helped to explain a great number of facts respecting certain high-level gravel terraces characterizing the Alleghany and Monongahela Rivers, which were surprisingly near the level of the water of the supposed glacial lake. At the meeting at Minneapolis Prof. Lesley, under whose vigilant eye the recent geological survey of Pennsylvania has been conducted, declared that he had for some time been expecting the discovery of a local obstruction to the drainage of the Ohio River which would account for the gravel terraces on the Alleghany and Monongahela to which reference has been made, and now, says he, Providence has provided it, and Wright's dam clears up the whole problem, or words to that effect.

Such was the boom with which the theory of the Cincinnati ice dam was brought before the public in 1883. During the ten years which have since elapsed, the hypothesis has been subject to much criticism, so that the faith of some has been shaken, and the theory itself is thought by many to be left in rather a damaged condition. The fullness with which the main facts have been already presented makes it possible to tell the remaining part of the story and state the present condition of the theory in few words.

So complicated are the forces of Nature that one discovery is sure to lead to another, and the man of science soon learns that he never exhausts attainable knowledge even in respect to the simplest subject, and the student has made little true advancement if he has not acquired ability to hold his mind wide open



Map II, showing the partly filled preglacial channel of the Ohio, extending from Cincinnati to the Big Miami at Hamilton. The figures show elevations above the sea.

for the reception of any and all additional facts which may modify and enlarge his theories. In the present case most interesting additions to our knowledge of the facts were made by Prof. Joseph F. James, who called attention to the breadth and depth of the valley running northward from Cincinnati to Hamilton, on the Great Miami River, and to the comparative narrowness and

shallowness of the present rocky gorge of the Ohio between Cincinnati * and the mouth of the Great Miami. The relative narrowness also of the latter opening between the rocky escarpments is readily visible to the transient traveler, Mill Creek Valley being about twice as wide as that of the Ohio for fifteen or twenty miles below the mouth of the creek; while a low passage joins Mill Creek at Ludlow Grove which sweeps around north of Walnut Hills, and enters the Ohio through the valley of the Little Miami—Walnut Hills, Mount Auburn, and Mount Lookout, the principal residence portions of the city, being upon a high, rocky pedestal completely surrounded by a depression which has at some time been produced by river erosion.

This valley from Cincinnati to Hamilton is now filled with gravel and clay to a great depth. Upon inquiring for the extent to which the old channel had been filled, it was found by the wells which had been sunk in it that the rock bottom descends from Cincinnati to Hamilton, and is considerably lower than the rock bottom of the present Ohio below Mill Creek. Near Ludlow Grove the bed rock is at least sixty feet below present low water in the Ohio. A few miles farther north, at Ivorydale, on Mill Creek, the bed rock where reached was found to be thirty-four feet below low-water mark in the Ohio, while there was nothing to show that in other portions of the valley the gravel was not still deeper. At Hamilton the bed rock was found to be at least ninety-one feet below the bottom of the Ohio River, showing that there is a deeply buried channel through Mill Creek Valley from Cincinnati to Hamilton; while, according to the inspector, Mr. C. J. Bates, upon building the piers for the great bridge of the Cincinnati Southern Railroad, which crosses the Ohio River near the west end of the city, it was found that the rock bottom was everywhere within a few feet of the low-water mark; thus fully justifying the inference of Prof. James, which can best be given in his own words:

"... Previous to the Glacial period a barrier of land extended from Price Hill on the north to the mouth of the Licking River on the south, preventing the westward flow of the Ohio, and forcing it north and northwest along the channels of Mill Creek and Duck Creek. These met at Ludlow Grove (near Cummingsville) and together continued north to Hamilton. Here entered the Great Miami, and the united streams continued in great volume southward to the present channel of the Ohio, at Lawrenceburg.

"At the coming on of the Glacial period a tongue of ice projecting down the valley from the north and surrounding the Cincinnati Island, as we may call that high land now covered with

* See Map II.

suburban homes, forced the water of the Ohio southward, over the watershed of the Licking, possibly into what is now the Kentucky River gorge. This course was pursued for an indefinite period; but, when the ice had retired, the river returned to its own channel near Cincinnati. Finding, however, its outlet to the north choked by *débris* of the glacier, and the former barrier of land between Price Hill and the mouth of the Licking lowered or cut away, it followed the line of drainage it holds at the present time.

"If the eye of savage man gazed upon the site of Cincinnati before the age of ice, he beheld a vastly different scene from what he would behold now. Standing on the highest point of Mount Auburn [Walnut Hills], he looked south over a deep, rocky gorge, through which rolled the mighty Ohio. On the west was the rocky shore of Price Hill extending in an unbroken line north and south to Kentucky. The Licking River entered as a tributary here. On the east was another waste of water rolling its dark tide northward, and joining the western branch beyond the hills of Clifton. No broad expanse of valley nor of rolling plain lay beneath him; no city was there, teeming with life and humming with industry; no railroad trains were panting and puffing, holding their way toward sites of unknown towns. But the water swiftly, with sullen roar re-echoing from cliff to cliff, pursued its journey toward its unknown grave. No steamer plowed its waters, but dugout or canoe probably carried primitive man from camp to camp or shore to shore. Where once the imaginary savage stood are now palatial mansions. Where once the waters spread their turbid tide is now a busy city of four hundred thousand people. The water which was once cleft only by the prow of frail canoe is now a highway for many floating palaces. Where once the stream pursued its northward course, the iron horse carries thousands daily to and from their homes in the wide and fertile Mill Creek Valley. Never would all this have been had not the Glacial period wrought its wondrous change. But the ice filled the valley and forced the river from its course. When permitted to return, the ancient channel was so filled with *débris* that a new one must be cut out, leaving the old one to be utilized by man as a way for his iron servant and as a place whereon to build his cities." *

An inspection of the general map (Map I) will show that this ancient deflection of the Ohio by way of Hamilton is in analogy with the course of the river in many other places, as at Beaver, Pa., and below Marietta, Ohio, and that Prof. James's discovery of the buried channel, showing the ancient deflection by way of

* Journal of the Cincinnati Society of Natural History, July–October, 1888, pp. 100, 101.

Hamilton, adds greatly to the significance of the ice obstruction at that point, for it extends the distance of it about fifty miles, and the distance covered by the ice beyond the original river bed twenty miles.

While every attempt to calculate the chronology of the Glacial period is necessarily but approximate, still we can get from certain data a pretty good idea of the relative periods of time occupied by different stages of the advance and retreat of the ice. It is clear that the obstruction of the Ohio near Cincinnati continued during the whole time occupied by the advance of the ice from Hamilton to its farthest point, ten miles southwest of Cincinnati—that is, during the advance of the ice front over a space of about thirty miles and until its retreat to Cincinnati again. The only statement approaching to definiteness which we are warranted in making concerning the rate of this advance is that it was probably the slowest which we should assign to any part of the movement of the great continental ice-sheet; for, being near the extreme point of extension, the equilibrium of forces must have been very nearly established, and the momentum of the glacier from the north was constantly diminished at the front by the increased rapidity with which a more genial climate was melting the ice. So to speak, the glacier was here getting upon doubtful territory and had carefully to consider every forward step, until finally, having reached the height of the Kentucky hills, the balance was turned, and the retreat began. It is altogether probable that this close balancing of forces resulted in an exceptionally slow movement from Hamilton to Cincinnati, causing the glacier to occupy many centuries, or even thousands of years, in that part of the march.

Something of a measure of this time is perhaps to be found in the erosion of the cross-cut from Cincinnati to the mouth of the Great Miami, which must have begun as soon as the obstruction of the valley near Hamilton first occurred. The length of this new channel of erosion is from twelve to fifteen miles; but how much of the work had been previously done by the small streams formed by the local drainage it is difficult now to calculate. Many such questions remain to reward the labors of local investigators. The general impression which I have received from a study of the facts is that a period of several thousand years may have been occupied by the ice-front in its advance from Hamilton to the farthest point in Kentucky and its subsequent retreat to the north side of the river.

But it is not to be supposed that this period was by any means one of dull uniformity in the history of that region, for upon the first formation of the dam at the bend of the old river at Hamilton, raising the water to the height of the rock obstruction across

the present gorge of the Ohio just below Cincinnati, the river would at once begin the process of cutting down its new channel. A waterfall of far larger proportions than Niagara must have been at once developed in the lower portion of this short cut, near the junction with the Great Miami, which would steadily wear back toward the old channel at Cincinnati, when, if the ice had not reached so far, the water level above the dam would be speedily lowered, but only to be raised again at a later time when the advancing ice reached its farthest extent and obstructed the newer channel. It is altogether probable, however, that this new channel below Cincinnati had not been lowered to its full extent before the maximum advance of the ice. If this were the case the final retreat of the ice across the river would leave a rocky barrier below Cincinnati, such as to maintain the water for a while at a level much higher than that maintained at the present time. There are some deposits up the river indicating that this was the case, as, for instance, some in Teazes Valley extending from the Kanawha River to Huntington. By reference to the first map it will be perceived that this valley is less than seven hundred feet above tide, but it is covered with several feet of very fine sediment, distributed evenly over the bottom of the valley, which must have been deposited in still water during the later stages of the Glacial period.

A glance at the first map will also show some other most interesting problems of change in drainage systems caused by the Glacial period which have not been adequately studied ; for example, it will be noticed that a stream rising near Madison, Ind., pursues a very singular course with reference to the contour lines. This is the Muscatatuck River, which rises within less than a mile of the Ohio River and four hundred feet above it; but instead of following the strike of the strata, as it naturally would, around to Louisville, it cuts across a broad north-and-south valley of erosion to join the East Branch of the White River, when both together, continuing on in a westerly course, follow a gorge several hundred feet deep through the highest portion of the State till they unite with the West Branch of the White River to reach the Ohio through the Wabash. It is extremely difficult to explain the course of this stream, except by some such process of reasoning as has been adopted with respect to the Ohio below Cincinnati. The projection of the tongue of ice which extended below Madison deflected the drainage of a considerable region through a partially formed pass across the elevated plateau to the west, while the morainic deposits about the farthest extension of the ice lobe permanently obstructed the channels in that direction, so that upon the withdrawal of the ice the Muscatatuck still continued to run into the Ohio by way of the Wabash.

As has been said, the first announcement of the Cincinnati ice dam was thought to give a natural and sufficient explanation for certain high-level gravel terraces occurring in the upper Ohio Valley. Subsequent investigations have brought to light other considerations which must more or less modify the first conclusions. It still remains true, however, that the ice dam accounts most naturally for many of the slack-water deposits which occur in the valley of the upper Ohio and its tributaries, while there are many areas which are yet but inadequately explored, but which promise important light upon the problem when the facts are all obtained. At the same time it appears that some of the terraces in the Alleghany and Monongahela Rivers are slightly higher than the obstruction at Cincinnati, compelling the advocates of the ice-dam theory to suppose some very probable changes of level since the deposition of the terraces which were at first supposed by Prof. Lesley to be so completely explained by it.

But more important is the bearing of recent discoveries upon the extent to which glacial gravels accumulated in the gorge of the upper Ohio and Alleghany Rivers, as shown in the section in the lower right-hand corner of Map. I. All along the Alleghany and Ohio Rivers there are remnants of gravel accumulations, from fifty to sixty feet deep, resting upon rock shelves about three hundred feet above the present rock bottom of the Ohio. There is now little reason to doubt that during the Glacial period the floods of water which poured into the Alleghany and the Ohio from all their northern tributaries brought along silt, gravel, and bowlders enough to fill up this rocky gorge with great rapidity, down as far probably as Wheeling. As the Alleghany River received glacial floods and glacial *débris* in great quantities, while the Monongahela did not receive any, it will be seen that the Monongahela must have been dammed by both the silt and the water which came down the Alleghany.

Instances in which the water of a tributary is dammed by that of the main stream will occur to any one upon a little reflection. Whenever one large tributary perceptibly rises, it raises the water level of the main stream as well above as below the junction, while a large rise in the main stream may temporarily reverse the current in a tributary. The Columbia River, for example, in Oregon, is subject to very extensive floods at seasons of the year when the Willamette is comparatively low. At such times a current sets up stream past the city of Portland. I remember, also, hearing, when a boy, the story of a June freshet on the Poultney River, in Vermont, caused by a succession of thunder-showers about its head waters. The rise in the lower part of the stream amounted to thirty or forty feet. The thing which fixed itself most deeply in my mind was that a milldam upon Hub-

bardton Creek, which was not affected by the showers, was carried up stream by the water which set back from the river. Thus it is easy to see that the glacial floods which poured into the Ohio from its northern tributaries would, during their continuance, produce slack water in its southern tributaries.

A more permanent class of dams is produced when a superabundant amount of earthy *débris* is contributed by one tributary of a stream. It is thus that the Chippewa River, in Wisconsin, has brought down an excessive amount of sand and gravel into the Mississippi, where, owing to the gentler gradient and the slower current in the larger valley, a delta has been pushed out across the Mississippi, ponding back the water so as to form the enlargement known as Lake Pepin. Dr. George M. Dawson describes a more striking instance in one of the principal tributaries of the Fraser in British Columbia, where Dead Man's Creek joins the Thompson. Here a sufficient amount of gravel has been brought down to silt up the main stream to a depth of four hundred and fifty feet, forming Kamloop's Lake, which is eighteen miles long and two miles wide. It is thus that the glacial silts coming into the channel of the Ohio from its northern tributaries have assisted the Cincinnati ice dam in the work that was laid upon it.

On the other hand, it is clear that the Cincinnati ice dam must in turn have assisted greatly in the silting process already referred to; for, as far up the Ohio as slack water was produced by the obstruction at Cincinnati, the deposition of the finer silt must have been greatly facilitated by it. At the same time the deposition of gravel near the mouth of the streams joining the Ohio above Cincinnati, and the obstruction offered by the rock strata, which have since been worn out in the new channel below Cincinnati, combined to relieve the ice gorge there from the supposed incredible hydraulic pressure which some have thought to be fatal to the hypothesis.

In conclusion, it may be said with a fair degree of confidence that the theory of the Cincinnati ice dam still "holds water," though the obstruction itself disappeared many thousand years ago. One may readily admit that some things were at first attributed to the dam which were the result of other causes. But fresh considerations have given increased interest to the theory, so that altogether it remains one of the most striking of all the episodes connected with geologic history, and it is all the more dramatic because of its probable connection with human history. There is, therefore, ample justification for the language of Prof. Claypole, in his paper upon the subject, read before the Geological Society of Edinburgh in 1887, and printed in the Transactions of that year.

Having described the desolation sometimes produced in Switzerland by the bursting of glacial lakes, he remarks that to a still greater extent the "period of conflict between the ice and the river must have been a terrible time for the lower Ohio Valley and its inhabitants. At times the river was dry, and at others bank-full and overflowing. The frost of winter, by lessening the supply, and the ice-tongue by forming a dam, combined to hold back the water. The sun of summer, by melting the dam, and the pressure of the accumulated water, by bursting it, combined to let off all at once the whole of the retained store. Terrible floods of water and ice, laden with stones, gravel, and sand, must have poured down the river and have swept away everything in their path—trees, animals, and man, if present.

"How many years or ages this conflict between the lake and the dam continued it is quite impossible to say, but the quantity of wreckage found in the valley of the lower Ohio, and even in that of the Mississippi, below their point of junction, is sufficient to convince us that it was no short time. 'The Age of Great Floods' formed a striking episode in the story of 'The Retreat of the Ice.' Long afterward must the valley have borne the marks of these disastrous torrents, far surpassing in intensity anything now known on the earth. The great flood of 1884, when the ice-laden water slowly rose seventy-one feet above low-water mark, will long be remembered by Cincinnati and its inhabitants. But that flood, terrible as it was, sinks into insignificance beside the furious torrent caused by the sudden even though partial breach of an ice dam hundreds of feet in height, and the discharge of a body of water held behind it, and forming a lake of twenty thousand square miles in extent.

"To the human dwellers in the Ohio Valley—for we have reason to believe that the valley was in that day tenanted by man—these floods must have proved disastrous in the extreme. It is scarcely likely that they were often forecast. The whole population of the bottom lands must have been repeatedly swept away; and it is far from being unlikely that in these and other similar catastrophes in different parts of the world, which characterized certain stages in the Glacial era, will be found the far-off basis on which rest those traditions of a flood that are found among all savage nations, especially in the north temperate zone."

Mr. W. H. Dines, an English meteorologist, is inclined to believe, from observations and experiments made with his new anemometer, that a gust seldom maintains its full power for more than one or two seconds; and that the extreme velocity occurs in lines which are roughly parallel to the direction of the wind.

THE EYE AS AN OPTICAL INSTRUMENT.

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I HAVE often wondered whether the statement, occasionally made by physicists, that the human eye is not a perfect optical instrument, is an expression of human vanity or of an imperfect knowledge of the anatomy of the eye and the physiology of vision; and I have come to the conclusion that the latter is the more reasonable theory. The approach to perfection in modern telescopes and microscopes is wonderful indeed; but as physiologists have advanced the knowledge of vision, the so-called imperfections of the eye have been steadily disappearing; and even now there is much to learn. Viewed merely as an optical instrument, an apparatus contained in a globe less than an inch in diameter, in which is produced an image practically perfect in form and color, which can be accurately adjusted almost instantly for every distance from five inches to infinity, is movable in every direction, has an area for the detection of the most minute details and at the same time a sufficient appreciation of large objects, is double, but the images in either eye exactly coinciding, enables us to see all shades of color, estimate distance, solidity, and to some extent the consistence of objects, the normal human eye may well be called perfect. The more, indeed, the eye is studied in detail, the more thoroughly does one appreciate its perfection as an optical apparatus.

Were it not for a slight projection of the cornea (the transparent covering in front) the eye would have nearly the form of a perfect globe a small fraction less than an inch in diameter. It lies in a soft bed of fat, is held in place by little muscles and a ligament which is so lubricated that its movements take place with the minimum of friction. It is protected by an overhanging bony arch and the eyelids, the eyelashes keeping away dust, and the eyebrows directing away the sweat. Situated thus in the orbit, the eyes may be moved to the extent of about forty-five degrees; but beyond this it is necessary to move the head.

The accuracy of vision depends primarily upon the formation of a perfect image upon the retina, which is a membrane, sensitive to light, connected with the optic nerve. That such an image is actually formed has been demonstrated by an instrument, the ophthalmoscope, which enables us to look into the eye and see the image itself. Although the image is inverted, the brain takes no cognizance of this, and every object is appreciated in its actual

position. The image is formed in the eye in the way in which an image is produced and thrown on a screen by a magic lantern.

When a ray of light passes obliquely from the air through glass, water or other transparent media, it is bent, or refracted, and the angle at which it is bent is called the index of refraction. In passing to the retina, the rays of light pass through the cornea, a watery liquid (the aqueous humor) surrounding the lens, the crystalline lens, and a gelatinous liquid (the vitreous humor) filling the posterior two thirds of the globe, all of which have the same index of refraction. This provides that a ray of light, having once passed through the cornea, is not refracted in passing through the other transparent media, except by the curvatures of the crystalline, which is a double-convex lens situated just behind the pupil. The rays of light are not reflected within the eye itself, for the opaque parts of the globe are lined with a black membrane (the choroid), as the tube of a microscope is blackened for a similar purpose. Practically, the bending of the rays of light is produced by the curved surface of the cornea and

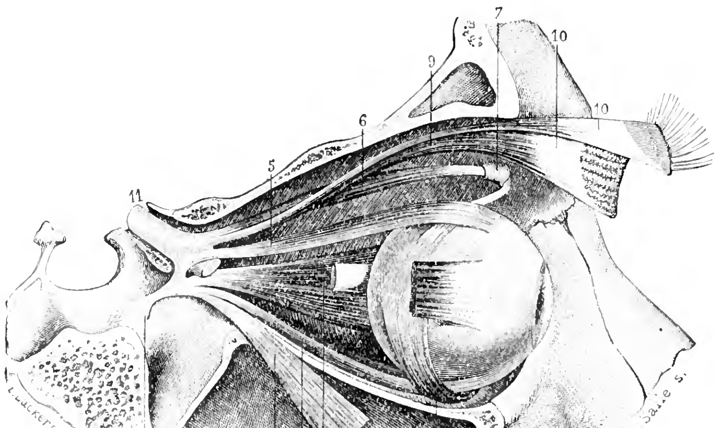

FIG. 1.—This figure gives a general view of the eyeball, the outer wall of the orbit being removed: 1, tendon of origin of three of the muscles of the eyeball; 2, the external straight muscle divided and turned down so as to expose the lower straight muscle; 3, 4, 5, 6, 7, 8, muscles moving the eyeball; 9, 10, 10, muscle which raises the upper eyelid; 11, optic nerve. (After Sappey.)

the two curved surfaces of the double-convex crystalline lens. These three curved surfaces bring the rays from an object to a focus exactly at the retina in a normal eye. When, however, the eye is too long, the focus is in front of the retina unless, in near vision, the object be brought very near the eye, and the person is near-sighted. For ordinary vision, such persons must wear prop-

erly adjusted concave glasses to carry the focus farther back. When the eye is too short, the focus is behind the retina, and the person is far-sighted and must wear convex glasses. The first condition is called myopia, and the second, hypermetropia; but in most persons who are obliged to wear convex glasses in ad-

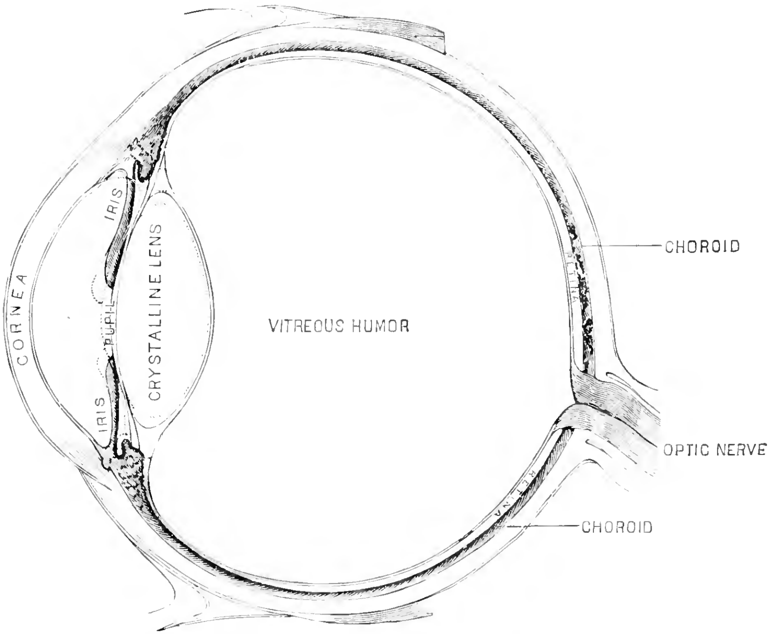

FIG. 2.—DIAGRAMMATIC SECTION OF THE HUMAN EYE.

vanced life, the crystalline lens has become flattened and inelastic, the diameter of the eye being unaltered. This condition is called presbyopia, which means a defect in vision due to old age.

One of the wonderful things about the eye is the mechanism by which a perfect image is formed. What is called the area of distinct vision is a depression in the yellow spot of the retina, which is probably not more than a thirty-sixth of an inch in diameter. It is with this little spot that we examine minute details of objects. If we receive the rays of light from an object upon a double-convex lens and throw them upon a screen in a darkened room, the image of the object appears upon the screen; but in order to render this image even moderately distinct it is necessary to carefully adjust the lens, or the combination of lenses, to a certain distance, which is different for lenses of different curvatures. In the human eye the adjustment is most accurately made, almost instantaneously, for any desired distance, not by changing the distance between the crystalline lens and the retina, but by changing the curvature of the crystalline lens itself. The way in

which this is done has been known only within the last few years. The lens is elastic, and in a quiescent, or what is called an indolent condition, is compressed between the two layers of the ligament which holds it in place. In this condition, when the rays from distant objects are practically parallel as they strike the eye, the lens is adjusted for infinite distance. When, however, we examine a near object, by the action of a little muscle within the eyeball the ligament is relaxed and the elastic lens becomes more convex. This action is called accommodation, and is volun-

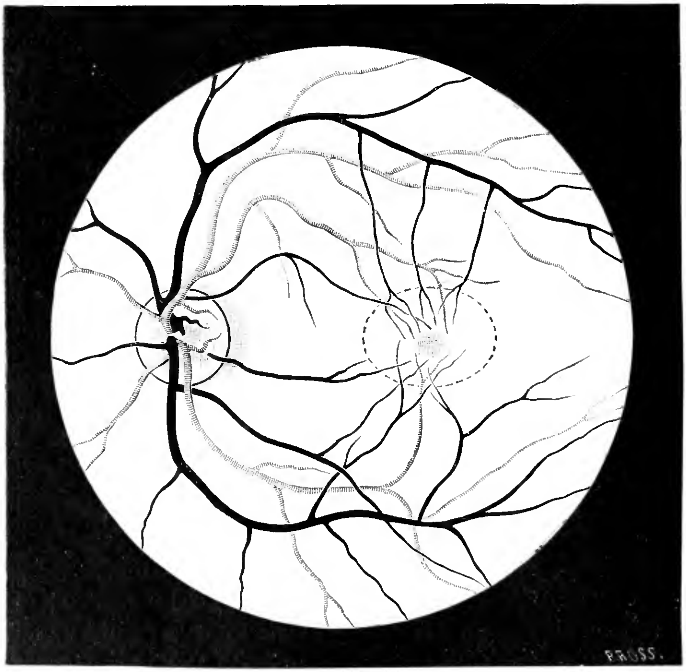

Fig. 3.—Visual Portion of the Retina as seen by the Ophthalmoscope; magnified about seven and a half diameters, showing the blood-vessels branching from the point of entrance of the optic nerve, and the yellow spot surrounded by the dotted oval. (After Loring.)

tary, though usually automatic. The fact that it is voluntary is illustrated by the very simple experiment of looking at a distant object through a gauze placed a few feet from the eye. When we see the distant object distinctly, we do not see the gauze; but by an effort we can distinctly see the meshes of the gauze, and then the object becomes indistinct. In some old persons the lens not only becomes flattened, but it loses a great part of its elasticity and the power of accommodation is nearly lost.

The changes in the curvatures of the lens in accommodation have been actually measured. The lens itself is only about a third

of an inch in diameter and its central portion is only a fourth of an inch thick. Adjusted for infinite distance, the front curvature has a radius of about four tenths of an inch, while for near objects the radius is only about three tenths of an inch. A curious experiment is looking at a minute object through a pinhole in a bit of paper or cardboard, when the object appears highly magnified. This is because the nearer the object is to the eye, the larger it appears. The shortest normal distance of distinct vision is about five inches; but in looking through a pinhole we can see at a distance of less than an inch, using a very small part of the central portion of the crystalline lens. Accommodation for very near objects is assisted, also, by contraction of a little band of fibers in the iris, about a fiftieth of an inch in width, immediately surrounding the pupil.

The most wonderful thing about the formation of a perfect image upon the retina is the mechanism of correction for form

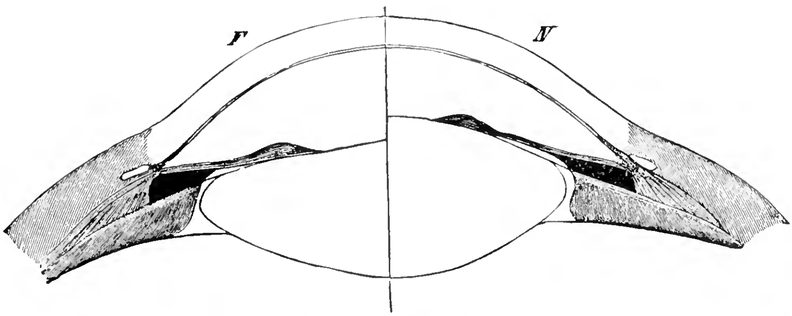

FIG. 4.—SECTION OF THE LENS SHOWING THE MECHANISM OF ACCOMMODATION. The left side of the figure (F) shows the lens adapted to vision at infinite distances. The right side of the figure (N) shows the lens adapted to the vision of near objects. (After Fick.)

and color. In grinding lenses for the microscope, for example, it is mechanically easy to make a very small convex lens with perfectly regular curvatures—that is, each curvature being a portion of a perfect sphere; but in such a lens the focus of the central portion is longer than that of the parts near the edge; and when an object is in focus for the center it is out of focus for the periphery. This is a fatal objection to the use of uncorrected lenses of high power; but in microscopes it is corrected by combinations of lenses, reducing the magnifying power, however, about one half. This is not all. When white light passes through a simple lens it is decomposed into the colors of the spectrum. This is called dispersion, and it surrounds the object with a fringe of colors. The dispersion by concave lenses is exactly the opposite of the dispersion by convex lenses, so that this may be corrected by a combination of the two; but when this is done with lenses made of precisely the same material, the magnifying power

is lost. Newton supposed that it was an impossibility to construct a lens corrected for color which would magnify objects; but since the discovery (in 1753 and 1757) of different kinds of glass having the same refractive power but widely different dispersive powers, perfect lenses have been possible.

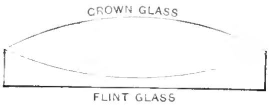

Fig. 5.—Achromatic Lens.

In the human eye, a practically perfect image, with no alteration in color, is produced by a mechanism which human ingenuity can not imitate. There is a slight error in the cornea, which is corrected by an opposite error in the crystalline lens; the iris plays the part of the diaphragm of optical instruments and shuts off the light from the borders of the crystalline lens, where the error is greatest, particularly in near vision; the curvatures of the lens are not perfectly spherical, but are such that the form of objects is not distorted; and while such curvatures are theoretically calculable, their construction is practically impossible, as experience has shown; different layers of the crystalline lens have different dispersive powers; and thus a practically perfect image, with no appreciable decomposition of white light, is formed on the retina.

Another wonderful thing about the eye, which adapts it most beautifully to our requirements, is the division of the sensitive parts of the retina into a very small area for distinct vision, which we use for reading, for example, and a large surrounding area in which vision is indistinct. If we saw with equal distinctness with all parts of the retina, the vision of minute objects would be confused and imperfect. As it is, the area of distinct vision is very small, probably less than one thirty-sixth of an inch in diameter. In this area, the distance between the separate sensitive elements is not more than one thirty-five-hundredth of an inch; while, if we pass from this only eight degrees, the distance is increased a hundred times. Still, in looking at any one object in the center of distinct vision, the imperfect forms of surrounding objects are appreciated, warning us, perhaps, of the approach of danger.

The mechanism of distinct and indistinct vision has been understood only since 1876. The sensitive parts of the retina are little rods and cones forming a layer by themselves. In 1876, Boll discovered that in frogs kept in the dark the rods of the retina were colored a dark purple; but on exposure to light the color faded, becoming first yellow and then white. Since that time, physiologists have been carefully investigating visual purple and visual yellow. Just outside the layer of rods and cones are the dark cells which render the greatest part of the interior of the eye almost black. In the dark, these cells send little filaments be-

tween the rods and discharge a liquid which colors the rods alone. When the rods are thus colored, the eye is extremely sensitive, so that a bright light is dazzling and painful and obscures distinct vision. This is the reason why we can not see distinctly when we come suddenly from the dark into a full light. In a few seconds, however, the color is bleached to a yellow and the difficulty passes away. When, on the other hand, we pass from a bright light into the dark, the retina has lost its sensibility from disappearance of the visual purple, and we can not see at all until the purple is reproduced, as it is in the absence of light. This difference is not due to dilatation of the pupil in the dark and contraction under the influence of light, as is popularly supposed, for a person does not see better in the dark when the pupil has been fully dilated by belladonna.

In the little area of distinct vision there is never any visual purple. This area we always use with sufficient light for minute details of objects, making then the greatest use of the mechanism of accommodation. The area outside of this is used for indistinct vision, and as the color is then yellow instead of purple, it is only moderately sensitive. To express the conditions in a few words, the minute area for distinct vision is used by day, and the area for indistinct vision, with its visual purple, is used by night.

A very curious condition is what is known as night-blindness. Sometimes, in long tropical voyages, sailors become affected with total blindness at night, while vision in the daytime is perfect. The glare of the sun in the long days bleaches the visual purple so completely that it can not be restored in a single night, and the area of indistinct vision becomes insensible. This trouble is purely local and is remedied by rest of the eye. If one eye be protected by a bandage during the day, this eye will be restored sufficiently for the next night's watch, while the unprotected eye is as bad as ever. Snow-blindness in the arctic regions is due to the same cause.

We receive the impression of a single object, although there are two images—one in either eye; but it is necessary that the images be made upon corresponding points in the two retinæ. If the angle of vision in one eye be deviated even to a slight degree by pressing on one globe with the finger, we see two images. One can appreciate how exactly these points must correspond when it is remembered that two rays of light appear as one only when the distance between them is one thirty-five-hundredth of an inch.

In either eye there is a blind spot, and this is at the point of penetration of the optic nerve; but, inasmuch as this spot is in the area of indistinct vision, and is so situated—a little within the line of distinct vision—that an impression is never made on both blind spots by the same object, this blindness is never appreciable,

and the spot can be detected only by the most careful investigation.

Not the least of the wonders of the eye are connected with the appreciation of images made upon the retina by certain parts of the brain. It is literally true that a person may see and yet not perceive. It has happened, in certain injuries of the brain, that a person sees and reads the words in a book and yet does not perceive their significance. This is called word-blindness. In a certain portion of the brain is a part which enables us to recognize the fact that we see an object; yet this object conveys no idea. There are two of these so-called centers of vision, one on either side, and their action is partly crossed. When the center is destroyed on one side, the inner half of one eye and the outer half of the other eye are blinded. Farther back in the brain, however, is a center which enables us to perceive or understand what is seen. When this center is destroyed we see objects and may avoid obstacles in walking, but persons, words, etc., are not recognized. This center exists only on the left side of the brain.

An impression, however short, made upon the retina is perceived. The letters on a printed page are distinctly seen when illuminated by an electric spark, the duration of which is only forty billionths of a second; but the impression remains much longer. Anything in motion appears to us in a way quite different from the single impression that we should have from an electric spark. In a picture representing an animal in motion, as it appears in an instantaneous photograph, the positions seems absurd and like nothing we have ever seen. In looking at a horse in action, the impressions made by the different position of the animal run into each other, and art should represent as nearly as possible the sum or average of these impressions. It is also true that impressions are diffused in the retina beyond the points upon which they are directly received. This is called irradiation; and the impression is diffused farther for white or light-colored than for black or dark objects. It is well known that a white square looks considerably larger than a dark square of exactly the same size; or the hands in white gloves look larger than in black gloves.

I have described, in as simple a way as possible, some wonderful things about the eye ascertained and explained by modern investigations; but there are many interesting facts ascertained which space has not permitted me to discuss, and there still remains much that is not yet understood. The whole question of the appreciation of colors and of color-blindness is still wrapped in mystery. We know that some persons can not distinguish between certain colors, but the reason of this is obscure. Perfect sight can exist only when the eye is perfect. The form and color of objects may be distorted so that an inaccurate

image is formed upon the retina, and this image, however imperfect it may be, is what is perceived by the brain. In hearing the case is different. The waves of sound, if they be conducted to the internal ear, and if the nerve of hearing, with its terminations, be normal, can not be modified in course of transmission. Sounds are always appreciated at their exact value, except as regards intensity. Enough has been said about the eye, I think, to show that it is perfectly adapted to all requirements, and whatever defects it may seem to have, viewed as an optical instrument, render it more useful to us than if these apparent defects did not exist.

THE KINDERGARTEN A NATURAL SYSTEM OF EDUCATION.

By JAMES L. HUGHES,
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THE kindergarten is a natural system of education, because it recognizes the natural laws of human growth, and supplies the necessary conditions to stimulate the special powers of each individual child. It recognizes the fact that each child has an individuality peculiarly its own, and that the greatest evil of school life in the past has been the dwarfing of individual power. No two children are alike, no two should be alike. All should be in unison by having the same desire to live for the right, but the powers of each and the methods of using them should be his own. The mightiest, holiest part of each individual is the quality or power in which he differs from all others. Schools generally manufacture men and women "to pattern." Whatever the ability, general or special, possessed by the different pupils of a class, they have all been expected to rise or fall to the same dead level. Usually the level has been very *dead.* The kindergarten is founded on the broad principle that the Creator had a special purpose in giving life to each child, and that the school should aid the child in becoming as nearly as possible what God meant him to be when he first let him enter the world. The kindergarten insists on the proper control of each child, because uncontrolled spontaneity commonly leads to anarchy and unbridled evil, but it never allows power to be destroyed by controlling it.

The kindergarten values the child more than the knowledge to be communicated to it or acquired by it. It values knowledge highly, but it places its highest estimate on the child, who has power to give the only real value to knowledge. It knows that the development of the child increases his capacity for gathering and using knowledge. It believes that the child's powers should

grow forever, that they grow most rapidly in early years, and that true growth in childhood is the only basis for the highest development of maturity. Therefore it makes the child and his universal tendencies and activities the chief study of the educator. The highest function of the teacher is not to select the knowledge most appropriate for children, or to decide the best plans for fixing it in their minds; his greatest study is the child and the ways in which he educates himself in those most prolific years before he goes to school. Some teachers claim that the teacher's duty is to teach the child how to "go." The child was set going long before he went to school. He was kept going before he went to school more rapidly than he ever goes after that time. Others say, the teacher's duty is to start the child to *grow*. How he had been growing before he went to school! How he grew physically; how his mind unfolded and defined itself; how his spiritual nature recognized the Creator in the wondrous material creation, and reached out to the mysteries of the unknown! He was ever going before he went to school, and growing because he was going. The reason he stops growing rapidly as soon as he goes to school is that his teachers interfere with his going. They stop his going altogether during school hours, and the reason he does not stop growing altogether physically, intellectually, and spiritually is that he is fortunately not kept in school all the time. How full of gratitude we should be for the fact that the blighting processes of the schoolroom last but six hours of five days in each week! We should be even more grateful when we remember that the school hours may become the most productive of the day in real growth. This is a part of the revelation which the kindergarten bears to all teachers who study it with sympathetic spirit. There is no good reason why the child's development should be checked after it goes to school. It should continue to improve with accelerated speed throughout life. Teachers will do vastly better than they do now when they keep up, after the child goes to school, the rate of advancement attained before he goes to school. They can never hope to do this until they study and understand the fundamental principles that underlie the motives of children, and guide them in the infinitely varied activities of their childish work and play. All their activities are in harmony with a divine purpose in the accomplishment of their fullest development. Man can best learn how to teach from the greatest teacher. His power and the unequaled success of his plans can be learned by the careful and continuous study of childhood. The teaching profession has been learning this fact from the kindergarten. There are several organized agencies already in existence for recording and comparing the characteristics, the tendencies, the habits, the activities, the capabilities, and the pro-

gressive development of children in different parts of the world. The new era has begun.

In the kindergarten the child's spontaneity is respected. He is not guided too much. He is allowed to work out, with the material given him, the plans, the designs, the problems, that arise in his own mind. The kindergarten dictates plans, designs, or problems to him only so far as may be necessary to help his mind to recognize new conceptions. He never has a lesson in which he is a follower or an imitator all the time. The idea that he should produce a result similar to his neighbor's is never presented to him. He is trained to depend on his own mind for the plan or design, and for its execution. Nature's plan before the child goes to school is to let him find his own problems. His greatest mental power is the ability to recognize in the material world by which he is surrounded the new things he has not seen before and the new problems he does not understand. If he has the privilege of growing up among the beauties of natural life, if the trees and flowers, and birds and butterflies, and bees and crickets, are his companions, if he has sand and stones and sticks for his playthings, there are few of the problems of science and material philosophy that do not present themselves to his mind. He solves thousands of them unaided, and brings those that are too deep for him to his mother or father, or most sympathetic older friend. These problems are not forced upon his mind by any external agency, they lie all around his path awaiting recognition by his mind. The recognition comes under such conditions exactly at the right moment, when the mind is ready to deal with the problem. No wonder that, under such conditions, knowledge is acquired and mental power defined and developed so rapidly. But when the child goes to school all these conditions are absolutely reversed. The teacher finds the problems and brings them to the child. Worse than this, the problems are those that suggest themselves to the teacher's mind and not the child's. Such problems can not be appropriate for the child. The problems suitable for one child can not be the best for other children at the same time. No mind but the child's own can decide the character of the problems suited to its present condition of development. Mind-growth can be dwarfed in no other way so completely as by the presentation of unsuitable problems. Loss of interest and loss of power, negation instead of positivity, indifference in place of aggressive wonderment, must follow when the child is forced to deal with problems that are not in harmony with his mental development.

One of the greatest improvements in school-teaching will be the placing of the children in such conditions that they may find their own problems. In the kindergarten this is the foundation

principle of mental growth. Self-activity does not mean activity in working out the directions of a teacher or any other superior mind; it means the revelation or execution of the conceptions of the child himself. The child's work should be self-expression, not imitation, not mere responsive action in accord with the suggestion of a teacher. "The children are not interested in study, and most of them need to be forced to learn; so it would be worse than folly to expect them to find problems for themselves." So says the teacher who has had no true inspiration, no clear enlightenment. My dear friend, it is quite true that the children are not interested in your problems. It is true, moreover, that the few who gratify you and their parents by paying attention to your problems and learning your lessons usually make weak men, lacking in originality and force. Every head boy who leaves school with a load of prizes in his arms and a load of knowledge in his head, and then becomes a respectable nonentity, is an unripe, falling apple to set educational Newtons thinking.

The pupils do rebel against your problems; but they do not rebel against the problems of Nature before they go to school. Wake up! There are apples falling all around you. The greatest development in school processes during the next twenty-five years will be the introduction into the schoolroom of appropriate material, calculated to stimulate the investigative and executive powers of children, and thus continue the natural educational processes that led to such rapid and definite growth before school life began.

By reversing Nature's plan, and bringing the problems to children, instead of allowing them to find them for themselves, teachers prevent the development of the power to recognize new problems. This is the most important of all intellectual powers. The solution of new problems is a simple matter when we can clearly recognize them. The ability to see the things yet unseen must precede the knowledge of the things yet unknown. The power to see new problems should grow in strength and clearness more rapidly than any other mental power. It can not grow unless it has the opportunity for exercise. The greatest teacher is the one who presents to the child the best opportunities for the recognition of new problems by his own mind, and the most perfect facilities for expressing or representing his new conceptions in material form. The wonderment of the child in regard to the material world should become much more than a mental stimulus; it should ultimately become our highest, broadest, keenest spiritual insight. We are ever in the midst of new spiritual problems that we fail to recognize, because our wonder power was not allowed to act up to its natural limit.

In the kindergarten, knowledge is made clear by the self-

activity of the child. All growth of human power is based on the self-activity of the individual to be developed. No thought is ever definite until it has been consciously lived out or wrought out. The kindergarten makes use of self-expression in the child to define the thought already in its mind, and to reveal new thought. There is no other way by which thought can be clearly revealed and defined. Self-activity on the part of the child secures four very important results: it enables the teacher to be sure that the child is paying attention to its work, it reveals the nature of the child's own conceptions, it is an accurate test of the clearness of the thought received from the instruction of the teacher, and it is the most productive incentive to originality.

In the kindergarten, knowledge is applied as it is gained. The old plan of learning definitions or tables, or the names or powers of letters, or the theoretical principles of any science as a preparation for practical work to be done in geometry, algebra, arithmetic, reading, or science, was not in harmony with natural laws of growth. It is unnatural to value knowledge of any kind for itself alone. Knowledge has no value except as it is used; and an assumed value based on any other foundation must be fictitious and misleading. The child should not be interested in knowledge that it is not required to use in some way. When it becomes conscious of a lack of knowledge that is essential to the accomplishment of any definite purpose in its mind, it needs no artificial stimulus to make it give active and persistent attention. The consciousness of necessity should precede the effort to acquire. The kindergarten leads the child to define knowledge by using it, and uses knowledge as soon as it is acquired.

The kindergarten trains the executive powers of children. Formerly only their receptive powers were cultivated. They were made receptacles for knowledge communicated by the teacher, and their powers of receiving knowledge independently were developed. When teachers had accomplished the two purposes of storing the minds of their pupils and training their powers of observation, so as to qualify them for gaining knowledge readily and accurately themselves, they were satisfied. Better teachers were soon convinced that the accumulation of knowledge by even the most perfect methods was not the true aim of education, and gradually the reflective power received attention as well as the receptive powers. The lesson that the kindergarten has for us is that the best training of the receptive and reflective powers is practically valueless unless the executive powers are trained too. It will not do to leave the training of the executive powers to the circumstances of life outside of school. The receptive powers receive a great deal of good training outside of school; so do the reflective powers; so, too, do the executive powers. There is

no reason for leaving the development of the executive powers to the conditions outside of school that does not apply with equal force to the culture of the receptive and reflective powers. Such a course would do away with schools altogether. There are two reasons that render the training of the executive powers of children absolutely essential in a complete education: First, the receptive and reflective powers are really useful to the individual and humanity only when they are made productive by executive ability; and, second, the training of the executive powers is the only way by which the receptive and reflective powers can be thoroughly cultivated. Nature's sequence is: Receive, reflect, use. The first two steps must be imperfect without the third. The kindergarten always completes the ascent; it never destroys the unity of the trinity.

The kindergarten makes children creative; or it is better to say that it preserves and utilizes their creative powers. Men and women were not intended to be mere imitators or servile followers of other men and women. They should be independent, original, creative. Man can not be creative as God is creative, but the divine in each human being gives him power to be and do what others have never been or done. There is something for each of us to discover and reveal; something for each to produce; something for each to add to the helpful agencies that serve to make man happier; something that will aid in the realization of the highest hopes of the heart of humanity. The kindergarten aims from the first to develop the truly productive more than the reproductive tendencies and talents of the child. It makes children not merely submissive and responsive, but suggestive, inventive, creative. The schools and universities will learn to do so in due time.

The discipline of the kindergarten is natural. It is based on love and executed by love. There is no heart whose feelings are not purified and ennobled by the consciousness of the love of another heart; no mind that is not aroused and stimulated to grander effort by the full sympathy of another mind. The young heart yearns for the mother-love, and there is no other who could make so perfect a teacher as the mother of the child to be taught, if her education and her time were sufficient for the work. There will come a time when noble mothers will train great daughters and sons for humanity to a much greater extent than they do now. As women more clearly realize their powers and their responsibilities, it will be impossible to satisfy them with the society customs of semi-civilization. The social instinct has been terribly degraded. The period of its ennobling is at hand, when social unity shall in no sense be formalism. The kindergarten emphasizes the need of mother-love as an educational force. It does

not propose that the kindergarten shall be a substitute for the mother; but it tries to provide for the little ones a beautiful home, where they may enjoy the sympathetic affection of a true woman's heart, and have at the same time the advantages of the culture of a trained educator. It is only when the child's nature opens to the light that its complete life grows; it is only when the child's heart is happy that its mind is free. In the true kindergarten no woman can find a place whose heart is not young, whose life is not pure, and whose aims are not unselfish. Love is the greatest controlling force and the greatest intellectual stimulus.

PLEASURES OF THE TELESCOPE.

By GARRETT P. SERVISS.

I.—THE SELECTION AND TESTING OF A GLASS.

IF the pure and elevated pleasure to be derived from the possession and use of a good telescope of three, four, five, or six inches aperture were generally known, I am certain that no instrument of science would be more commonly found in the homes of intelligent people. The writer, when a boy, discovered unexpected powers in a pocket telescope not more than fourteen inches long when extended, and magnifying ten or twelve times. It became his dream, which was afterward realized, to possess a more powerful telescope, a real astronomical glass, with which he could see the beauties of the double stars, the craters of the moon, the spots on the sun, the belts and satellites of Jupiter, the rings of Saturn, the extraordinary shapes of the nebulæ, the crowds of stars in the Milky Way, and the great stellar clusters. And now he would do what he can to persuade others, who perhaps are not aware how near at hand it lies, to look for themselves into the wonder-world of the astronomers.

There is only one way in which you can be sure of getting a good telescope. First, decide how large a glass you are to have, then go to a maker of established reputation, fix upon the price you are willing to pay—remembering that good work is never cheap—and finally see that the instrument furnished to you answers the proper tests for a telescope of its size. There are telescopes and telescopes. Occasionally a rare combination of perfect homogeneity in the material, complete harmony between the two kinds of glass of which the objective is composed, and lens surfaces whose curves are absolutely right, produces a telescope whose owner would part with his last dollar sooner than with it. Such treasures of the lens-maker's art can not, perhaps, be com-

manded at will, yet they are turned out with increasing frequency, and the best artists are generally able, at all times, to approximate so closely to perfection that any shortcoming may be disregarded.

In what is said above I refer, of course, to the refracting telescope, which is the form of instrument that I should recommend to all amateurs in preference to the reflector. But, before proceeding further, it may be well to recall briefly the principal

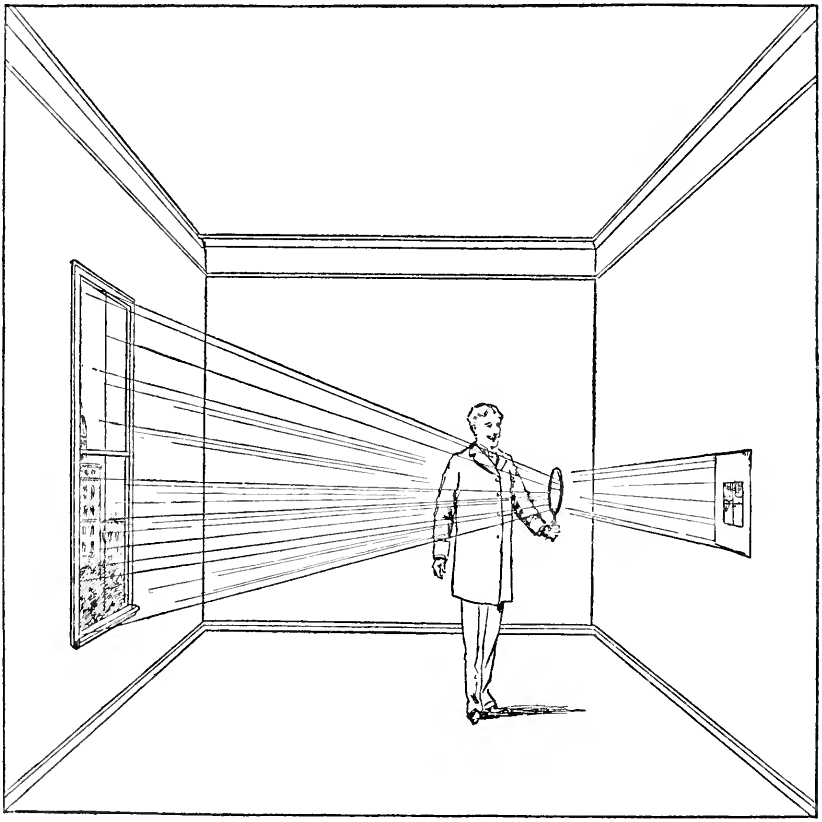


Fig. 1.—Image at the Focus of a Lens.

points of difference between these two kinds of telescopes. The purpose of a telescope of either description is, first, to form an image of the object looked at by concentrating the rays of light proceeding from that object at a focus. The refractor achieves this by means of a carefully shaped lens, called the object glass, or objective. The reflector, on the other hand, forms the image at the focus of a concave mirror.

A very pretty little experiment, which illustrates these two methods of forming an optical image, and, by way of corollary,

illustrates the essential difference between refracting and reflecting telescopes, may be performed by any one who possesses a reading glass and a magnifying hand mirror. In a room that is not too brightly illuminated pin a sheet of white paper on the wall opposite to a window that, by preference, should face the north, or away from the position of the sun. Taking first the reading glass, hold it between the window and the wall parallel to the sheet of paper, and a foot or more distant from the latter. By moving it to and fro a little you will be able to find a distance, corresponding to the focal length of the lens, at which a picture of the window is formed on the paper. This picture, or image, will be upside down, because the rays of light cross at the focus. By moving the glass a little closer to the wall you will cause the picture of the window to become indistinct, while a beautiful image of the houses, trees, or other objects of the outdoor world beyond, will be formed upon the paper. We thus learn that the distance of the image from the lens varies with the distance of the object whose image is formed. In precisely a similar manner an image is formed at the focus of the object glass of a refracting telescope.

Take next your magnifying or concave mirror, and detaching the sheet of paper from the wall, hold it nearly in front of the mirror between the latter and the window. When you have adjusted the distance to the focal length of the mirror, you will see an image of the window projected upon the paper, and by varying the distance, as before, you will be able to produce, at will, pictures of nearer or more remote objects. It is in this way that images are formed at the focus of the mirror of a reflecting telescope.

Now, you will have observed that the chief apparent difference between these two methods of forming an image of distant objects is that in the first case the rays of light, passing through the transparent lens, are brought to a focus on the side opposite to that where the real object is, while in the second case the rays, being reflected from the brilliant surface of the opaque mirror, come to a focus on the same side as that on which the object itself is. From this follows the most striking difference in the method of using refracting and reflecting telescopes. In the refractor the observer looks toward the object; in the reflector he looks away from it. Sir William Herschel made his great discoveries with his back to the sky. He used reflecting telescopes. This principle, again, can be readily illustrated by means of our simple experiment with a reading glass and a magnifying mirror. Hold the reading glass between the eye and a distant object with one hand, and with the other hand place a smaller lens such as a pocket magnifier, near the eye, and in line with the reading glass.

Move the two carefully until they are at a distance apart equal to the sum of the focal lengths of the lenses, and you will see a magnified image of the distant object. In other words, you have constructed a simple refracting telescope. Then take the magnifying mirror, and, turning your back to the object to be looked at, use the small lens as before—that is to say, hold it between your eye and the mirror, so that its distance from the latter is equal to the sum of the focal lengths of the mirror and the lens,

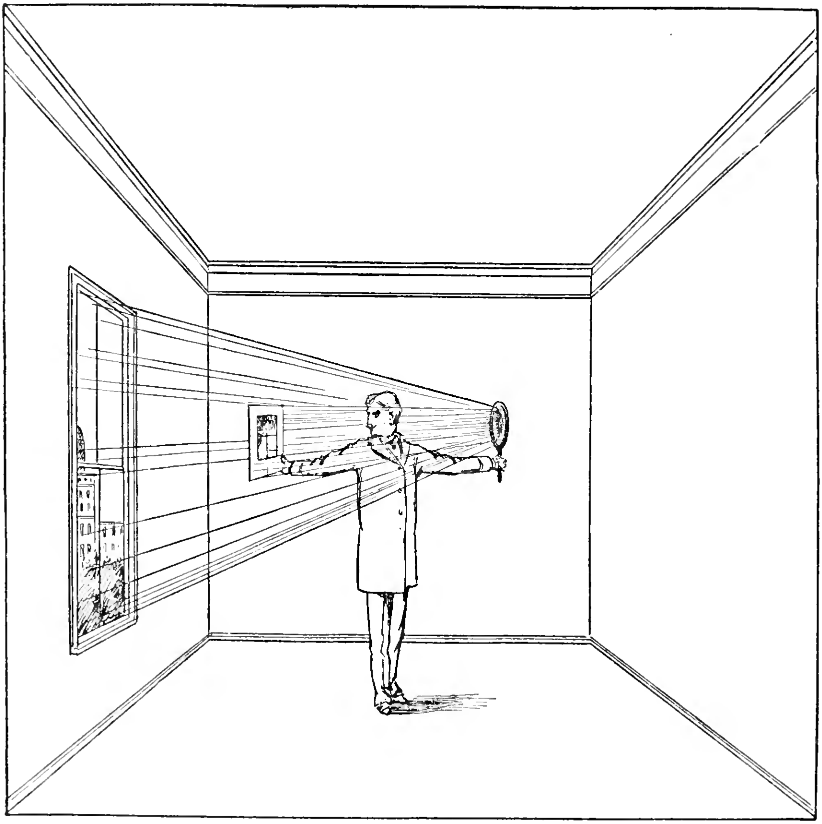


FIG. 2.—IMAGE AT THE FOCUS OF A CONCAVE MIRROR.

and you will see again a magnified image of the distant object. This time it is a reflecting telescope that you hold in your hands.

The magnification of the image reminds us of the second purpose which is subserved by a telescope. A telescope, whether refracting or reflecting, consists of two essential parts, the first being a lens, or a mirror, to form an image, and the second a microscope, called an eyepiece, to magnify the image. The same eyepieces will serve for either the reflector or the refractor. But in order that the magnification may be done with effect, and

serve to reveal what could not be seen without it, the image itself must be as nearly perfect as possible; this requires that every ray of light that forms the image shall be brought to a point in the image precisely corresponding to that from which it emanates in the real object. In reflectors this is effected by giving a parabolic form to the concave surface of the mirror. In refractors there is a twofold difficulty to be overcome. In the first place, a lens with spherical surfaces does not bend all the rays that pass through it to a focus at precisely the same distance. The rays that pass near the outer edge of the lens have a shorter focus than that of the rays which pass near the center of the lens; this is called spherical aberration. A similar phenomenon occurs with a concave mirror whose surface is spherical. In that case, as we have seen, the difficulty is overcome by giving the mirror a parabolic instead of a spherical form. In an analogous way the spherical aberration of a lens can be corrected by altering its curves, but the second difficulty that arises with a lens is not so easily disposed of: this is what is called chromatic aberration. It is due to the fact that the rays belonging to different parts of the spectrum have different degrees of refrangibility, or, in other words, that they come to a focus at different distances from the lens; and this is independent of the form of the lens. The blue rays come to a focus first, then the yellow, and finally the red. It results from this scattering of the spectral rays along the axis of the lens that there is no single and exact focus where all meet, and that the image of a star, for instance, formed by an ordinary lens, even if the spherical aberration has been corrected, appears blurred and discolored. There is no such difficulty with a mirror, because there is in that case no refraction of the light, and consequently no splitting up of the elements of the spectrum.

In order to get around the obstacle formed by chromatic aberration it is necessary to make the object glass of a refractor consist of two lenses, each composed of a different kind of glass. One of the most interesting facts in the history of the telescope is that Sir Isaac Newton could see no hope that chromatic aberration would be overcome, and accordingly turned his attention to the improvement of the reflecting telescope and devised a form of that instrument which still goes under his name. And even after Chester More Hall in 1729, and John Dollond in 1757, had shown that chromatic aberration could be nearly eliminated by the combination of a flint-glass lens with one of crown glass, William Herschel, who began his observations in 1774, devoted his skill entirely to the making of reflectors, seeing no prospect of much advance in the power of refractors.

A refracting telescope which has been freed from the effects of chromatic aberration is called achromatic. The principle upon

which its construction depends is that by combining lenses of different dispersive power the dispersion of the spectral colors can be corrected while the convergence of the rays of light toward a focus is not destroyed. Flint glass effects a greater dispersion than crown glass nearly in the ratio of three to two. The chromatic combination consists of a convex lens of crown backed by a concave, or plano-concave, lens of flint. When these two lenses are made of focal lengths which are directly proportional to their dispersions, they give a practically colorless image at their common focus. The skill of the telescope-maker and the excellence of his work depend upon his selection of the glasses to be combined and his manipulation of the curves of the lenses.

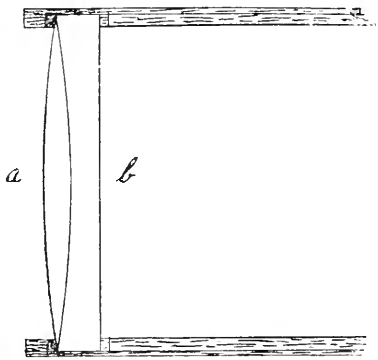


FIG. 3.—ACHROMATIC OBJECT GLASS. *a*, crown glass; *b*, flint glass.

Now, the reader may ask, "Since reflectors require no correction for color dispersion, while that correction is only approximately effected by the combination of two kinds of lenses and two kinds of glass in a refractor, why is not the reflector preferable to the refractor?"

The answer is, that the refractor gives more light and better definition. It is superior in the first respect because a lens transmits more light than a mirror reflects. Prof. Young has remarked that about eighty-two per cent of the light reaches the eye in a good refractor, while "in a Newtonian reflector, in average condition, the percentage seldom exceeds fifty per cent, and more frequently is lower than higher." The superiority of the refractor in regard to definition arises from the fact that any distortion at the surface of a mirror affects the direction of a ray of light three time as much as the same distortion would do at the surface of a lens. And this applies equally both to permanent errors of curvature and to temporary distortions produced by strains and by inequality of temperature. The perfect achromatism of a reflector is, of course, a great advantage, but the chromatic aberration of refractors is now so well corrected that their inferiority in that respect may be disregarded. It must be admitted that reflectors are cheaper and easier to make, but, on the other hand, they require more care, and their mirrors frequently need resilvering, while an object glass with reasonable care never gets seriously out of order, and will last for many a lifetime.

Enough has now, perhaps, been said about the respective

properties of object glasses and mirrors, but a word should be added concerning eyepieces. Without a good eyepiece the best telescope will not perform well. The simplest of all eyepieces is a single double-convex lens. With such a lens the magnifying power of the telescope is measured by the ratio of the focal length of the objective to that of the eye lens. Suppose the first is sixty inches and the latter half an inch; then the magnifying power will be a hundred and twenty diameters—i. e., the disk of a planet, for instance, will be enlarged a hundred and twenty times along each diameter, and its area will be enlarged the square of a hundred and twenty, or fourteen thousand four hundred times. But in reckoning magnifying power, diameter, not area, is always considered. For practical use an eyepiece composed of an ordinary single lens is seldom advantageous, because good definition can only be obtained in the center of the field. Lenses made according to special formulæ, however, and called solid eyepieces, give excellent results, and for high powers are often to be preferred to any other. The eyepieces usually furnished with telescopes are, in their essential principles, compound microscopes, and they are of two descriptions, "positive" and "negative." The former generally goes under the name of its inventor, Ramsden, and the latter is named after the great Dutch astronomer, Huygens. The Huygens eyepiece consists of two plano-convex lenses whose focal

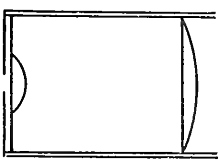


Fig. 4.—Negative Eyepiece.

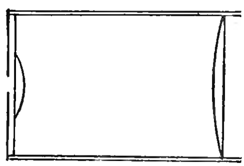


Fig. 5.—Positive Eyepiece.

lengths are in the ratio of three to one. The smaller lens is placed next to the eye. Both lenses have their convex surfaces toward the object glass, and their distance apart is equal to half the sum of their focal lengths. In this kind of eyepiece the image is formed between the two lenses, and if the work is properly done such an eyepiece is achromatic. It is therefore generally preferred for mere seeing purposes. In the Ramsden eyepiece two plano-convex lenses are also used, but they are of equal focal length, are placed at a distance apart equal to two thirds of the focal length of either, and have their convex sides facing one another. With such an eyepiece the image viewed is beyond the farther or field lens instead of between the two lenses, and as this fact renders it easier to adjust wires or lines for measuring purposes in the focus of the eyepiece, the Ramsden construction is used when a micrometer is to be employed. In order to ascertain

the magnifying power which an eyepiece gives when applied to a telescope it is necessary to know the equivalent, or combined, focal length of the two lenses. Two simple rules, easily remembered, supply the means of ascertaining this. The equivalent focal length of a negative or Huygens eyepiece is equal to half the focal length of the larger or field lens. The equivalent focal length of a positive or Ramsden eyepiece is equal to three fourths of the focal length of either of the lenses. Having ascertained the equivalent focal length of the eyepiece, it is only necessary to divide it into the focal length of the object glass (or mirror) in order to know the magnifying power of your telescope when that particular eyepiece is in use.

A first-class object glass (or mirror) will bear a magnifying power of one hundred to the inch of aperture when the air is in good condition—that is, if you are looking at stars. If you are viewing the moon, or a planet, better results will always be obtained with lower powers—say fifty to the inch at the most. And under ordinary atmospheric conditions a power of from fifty to seventy-five to the inch is far better for stars than a higher power. With a five-inch telescope that would mean from two hundred and fifty to three hundred and seventy-five diameters, and such powers should only be applied for the sake of separating very close double stars. As a general rule, the lowest power that will distinctly show what you desire to see gives the best results. The experienced observer never uses as high powers as the beginner does. The number of eyepieces purchased with a telescope should never be less than three—a very low power—say ten to the inch; a very high power, seventy-five or one hundred to the inch, for occasional use; and a medium power—say forty to the inch—for general use. If you can afford it, get a full battery of eyepieces—six or eight, or a dozen—for experience shows that different objects require different powers in order to be best seen, and, moreover, a slight change of power is frequently a great relief to the eye.

There is one other thing of great importance to be considered in purchasing a telescope—the mounting. If your glass is not well mounted on a steady and easily managed stand, you might better have spent your money for something more useful. I have endured hours of torment while trying to see stars through a telescope that was shivering in the wind and dancing to every motion of the bystanders, to say nothing of the wriggling contortions caused by the application of my own fingers to the focussing screw. The best of all stands is a solid iron pillar firmly fastened into a brick or stone pier, sunk at least four feet in the ground, and surmounted by a well-made equatorial bearing whose polar axis has been carefully placed in the meridian. It can be readily

protected from the weather by means of a wooden hood or a rubber sheet, while the tube of the telescope may be kept indoors, being carried out and placed on its bearing only when observations are to be made. With such a mounting you can laugh at the observatories with their cumbersome domes, for the best of all observatories is the open air. But if you dislike the labor of carrying and adjusting the tube every time it is used, and are both fond of and able to procure luxuries, then, after all, perhaps, you had better have the observatory, dome, draughts and all.

The next best thing in the way of a mounting is a portable tripod stand. This may be furnished either with an equatorial bearing for the telescope, or an altazimuth arrangement which permits both up-and-down and horizontal motions. The latter is cheaper than the equatorial and proportionately inferior in usefulness and convenience. The essential principle of the equatorial bearing is motion about two axes placed at right angles to one another. When the polar axis is in the meridian, and inclined at an angle equal to the latitude of the place, the telescope can be moved about the two axes in such a way as to point to any quarter of the sky, and the motion of a star, arising from the earth's rotation, can be followed hour after hour without disturbing the instrument. When thus mounted, the telescope may be driven by clockwork, or by hand with the aid of a screw geared to a handle carrying a universal joint.

And now for testing the telescope. It has already been remarked that the excellence of a telescope depends upon the perfection of the image formed at the focus of the objective. In what follows I have only a refractor in mind, although the same principle would apply to a reflector. With a little practice anybody who has a correct eye can form a fair judgment of the excellence of a telescopic image. Suppose we have our telescope steadily mounted out of doors (if you value your peace of mind you will not try to use a telescope pointed out of a window, especially in winter), and suppose we begin our observations with the pole star, employing a magnifying power of sixty or seventy to the inch. Our first object is to see if the optician has given us a good glass. If the air is not reasonably steady we had better postpone our experiment to another night, because we shall find that the star as seen in the telescope flickers and "boils," and behaves in so extraordinary a fashion that there is no more definition in the image than there is steadiness in a bluebottle buzzing on a window pane. But if the night is a fine one the star image will be quiescent, and then we may note the following particulars: The real image is a minute bright disk, about one second of arc in diameter if we are using a four-and-a-half or five-inch telescope, and surrounded by one very thin ring of light, and the

fragments, so to speak, of one or possibly two similar rings a little farther from the disk, and visible, perhaps, only by glimpses. These "diffraction rings" arise from the undulatory nature of light, and their distance apart as well as the diameter of the central disk depend upon the length of the waves of light. If the telescope is a really good one, and both object glass and eyepiece are properly adjusted, the disk will be perfectly round, slightly softer at the edge, but otherwise equally bright throughout; and the ring or rings surrounding it will be exactly concentric, and not brighter on one side than on another. Even if our telescope were only two inches or two inches and a half in aperture we should at once notice a little bluish star, the mere ghost of a star in a small telescope, hovering near the pole star. It is the celebrated "companion," but we shall see it again when we have more time to study it. Now let us put the star out of focus by turning the focusing screw. Suppose we turn it in such a way that the eyepiece moves slightly outside the focus, or away from the object glass. Very beautiful phenomena immediately begin to make their appearance. A slight motion outward causes the little disk to expand perceptibly, and just as this expansion commences, a bright-red point appears at the precise center of the disk. But, the outward motion continuing, this red center disappears, and is replaced by a blue center, which gradually expands into a sort of flare over the middle of the disk. The disk itself has in the mean time enlarged into a series of concentric bright rings, graduated in luminosity with beautiful precision from center toward circumference. The outermost ring is considerably brighter, however, than it would be if the same gradation applied to it as applies to the inner rings, and it is surrounded, moreover, on its outer edge by a slight flare which tends to increase its apparent width. Next let us return to the focus and then move the eyepiece gradually inside the focal point or plane. Once more the star disk expands into a series of circles, and, if we except the color phenomena noticed outside the focus, these circles are precisely like those seen before in arrangement, in size, and in brightness. If they were not the same, we should pronounce the telescope to be imperfect. There is one other difference, however, besides the absence of the blue central flare, and that is a faint reddish edging around the outer ring when the expansion inside the focus is not carried very far. Upon continuing to move the eyepiece inside or outside the focus we observe that the system of rings becomes larger, while the rings themselves rapidly increase in number, becoming at the same time individually thinner and fainter.

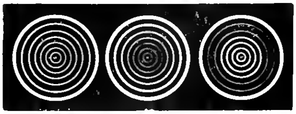
Fig. 6.—The Star Image.

By studying the appearance of the star disk when in focus and

of the rings when out of focus on either side, an experienced eye can readily detect any fault that a telescope may have. The amateur, of course, can only learn to do this by considerable practice. Any glaring and serious fault, however, will easily make itself manifest. Suppose, for example, we observe that the image of a star instead of being perfectly round is oblong, and that a similar defect appears in the form of the rings when the eyepiece is put out of focus. We know at once that something is wrong; but the trouble may lie either in the object glass, in the eyepiece, in the eye of the observer himself, or in the adjustment of the lenses in the tube. A careful examination of the image and the out-of-focus circles will enable us to determine with which of these sources of error we have to deal. If the star image when in focus has a sort of wing on one side, and if the rings out of focus expand eccentrically, appearing wider and larger on one side than on the other, being at the same time brightest on the least expanded side, then the object glass is probably not at right angles to the axis of the tube and requires readjustment. That part of the object glass on the side where the rings appear most expanded and faintest needs to be pushed slightly inward. This can be effected by means of counterscrews placed for that purpose in or around the cell. But if, after we have got the object glass properly squared to the axis of the tube or the line of sight, the image and the ring system in and out of focus still appear oblong, the fault of astigmatism must exist either in the objective, the eyepiece, or the eye. The chances are very great that it is the eye itself that is at fault. We may be certain of this if we find, on turning the head so as to look into the telescope with the eye in different positions, that the oblong image turns with the head of the observer, keeping its major axis continually in the same relative position with respect to the eye. The remedy then is to consult an oculist and get a pair of cylindrical eyeglasses. If the oblong image does not turn round with the eye, but does turn when the eyepiece is twisted round, then the astigmatism is in the latter. If, finally, it does not follow either the eye or the eyepiece, it is the objective that is at fault.

But instead of being oblong, the image and the rings may be misshapen in some other way. If they are three-cornered, it is probable that the object glass is subjected to undue pressure in its cell. This, if the telescope has been brought out on a cool night from a warm room, may arise from the unequal contraction of the metal work and the glass as they cool off. In fact, no good star image can be got while a telescope is assuming the temperature of the surrounding atmosphere. Even the air inclosed in the tube is capable of making much trouble until its temperature has sunk to the level of that outside. Half an hour at least is re-

quired for a telescope to adjust itself to out-of-door temperature, except in the summer time, and it is better to allow an hour or two for such adjustment in cold weather. Any irregularity in the shape of the rings which persists after the lenses have been accurately adjusted and the telescope has properly cooled may be ascribed to imperfections, such as veins or spots of unequal density in the glass forming the objective.



1 2 3

Fig. 7.—The Out-of-Focus Rings. 1, Correct figure; 2 and 3, spherical aberration.

The spherical aberration of an object glass may be undercorrected or overcorrected. In the former case the central rings inside the focus will appear faint and the outer ones unduly strong, while outside the focus the central rings will be too bright and the outer ones too feeble. But if the aberration is overcorrected the central rings will be overbright inside the focus and abnormally faint outside the focus.

Assuming that we have a telescope in which no obvious fault is discernible, the next thing is to test its powers in actual work. In what is to follow I shall endeavor to describe some of the principal objects in the heavens from which the amateur observer may expect to derive pleasure and instruction, and which may at the same time serve as tests of the excellence of his telescope.

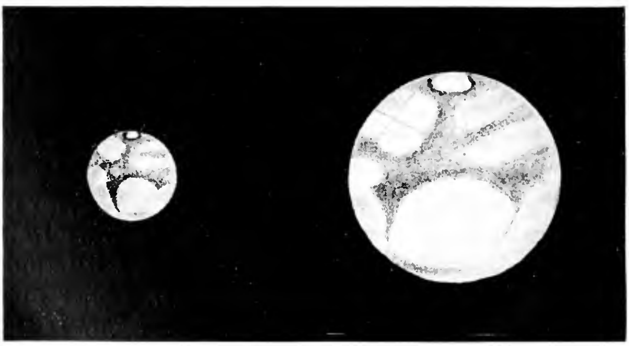


Fig. 8.—Two Views of Mars in 1892. The smaller with a three and three eighths inch telescope; the larger with a nine inch.

No one should be deterred or discouraged in the study of celestial objects by the apparent insignificance of his means of observation. The accompanying pictures of the planet Mars may serve as an indication of the fact that a small telescope is frequently capable of doing work that appears by no means contemptible when placed side by side with that of the greater instruments of the observatories.

SHOULD PROHIBITORY LAWS BE ABOLISHED?

By T. D. CROTHERS, M.D.

MR. APPLETON MORGAN, in the March number of The Popular Science Monthly, affirms that all prohibitory liquor laws should be abolished. Naturally, the reader inquires for what reasons and upon what evidence, and expects to find a grouping of facts that will at least give some support to these claims. If, on the contrary, the author assumes that the reader will credulously accept his confident statements as facts, it is to be supposed that such statements will be in accord with common observation, historical facts, and experience; if they fail in this, and are not sustained by any general examination, it is safe to conclude that the purpose of the paper is not to present the truth, and the author is a partisan, having some other object to accomplish not apparent in his writings.

The magnitude and intensely practical character of the question of prohibitory laws seem to demand some examination of the author's assertions. He begins with this: "The absolute, unqualified, and distinguished failure of all laws for the abolishment of the traffic in liquors is speedily convincing even the most sanguine prohibitionists of the expediency of wiping them from every statute book in the land."

In the failure to refer to authority for this statement the reader must examine for himself. Political records in yearly volumes, and histories of political reform, give no evidence or names of sanguine or other prohibitionists who are convinced of the failure of such laws.

Governors of States where prohibition laws are in force have without exception declared in their favor. Some have suggested modifications and changes from the present form, but all have affirmed their great value in securing better observance of law and order.

In 1889 a canvass was made of the opinions of judges, Congressmen, mayors of cities, superintendents of schools, journalists, manufacturers, postmasters, and others in the State of Maine, asking their opinion of the practical value of the existing prohibitory laws. In one hundred and forty replies only seven expressed any doubt, the others were confident and enthusiastic. Similar canvasses made in Vermont, Rhode Island, Kansas, Iowa, and in States where prohibition had been tried, brought out the same unanimous replies from equally eminent men, who were not in any way identified with the party of prohibition.

These and other systematic inquiries have been published in the New York Voice, a leading prohibition paper, and are cer-

tainly entitled to credence from the fearless, independent character of the replies. Turning to the Brewers' Journal and the Wine and Spirit Circular, which are supposed to represent those opposed to all prohibitory laws, the statements which are presented are of such a startling character, showing the failure of such laws, as to create doubt of their accuracy. The evidence in both of these journals and their reports is so intensely partisan and extreme as statements of alleged facts as to appear unfair and doubtful.

The census reports of 1880 and 1890 show a marked decrease of crime, pauperism, drunkenness, and arrests in all the States where prohibition is in force. No matter how these facts are explained, they do not support the statement that prohibition is a distinguished failure.

The author continues: "These laws never had any adequate or logical reason for existing at all. They have had their origin always and without exception in sparsely settled communities, where personal liberty was so absolute that it became irksome, where liquor was almost unknown, and its use a curiosity, and where the only knowledge of the horrors of intoxication the village possessed was derived from itinerant temperance orators, who dilated upon the terrible consequences of the rum habit to a roomful of tearful old women, none of whom knew the taste of liquor stronger than green tea."

The first sentence of this quotation must be accepted exclusively on faith, for there are no reasons for supposing that the long lists of philosophers, reformers, and leaders who have urged prohibitory laws were stupid, illogical, and unable to realize and reason on a certain line of facts. The rest of the paragraph ignores all early history of the origin of prohibitory legislation. The author has overlooked the fact that prohibitionary laws were enacted in Judea, Egypt, Greece, and Rome long centuries ago; also that Xenophon, Plato, and Aristotle discussed these questions, and Homer and Herodotus declared that "prohibitory laws would save men from becoming beasts." If the author will turn to his copy of Rollin's Ancient History, Montesquieu's Spirit of Laws, and Whewell's Platonic Dialogues, and his Morality and Polity, he will find his assertions out of harmony with the facts.

Along in this connection he asserts that the New England Puritan "no more thought of prohibiting the drinking of liquor than the preaching eight or ten hour sermons." Here again the facts of history are ignored. Laws were passed in Massachusetts, Connecticut, and Rhode Island, as early as 1640, prohibiting the sale of liquor to Indians, negroes, and mulatto slaves, and earlier than this innkeepers were prohibited from selling spirits after nine o'clock at night, and on Sunday, or to drunken men. The

Puritans for over a hundred years were struggling to prohibit the sale of liquor under certain conditions, and colonial and later laws regulating who should sell spirits, and when, and to whom, and under what conditions, would fill a volume. Volumes of sermons preached during this time will show that prohibition was a very serious topic; one of the reasons held was that intoxication was due to direct Satanic influence.

The reiteration that the various statutes against the selling of liquor are not for the general good, and do not come from a demand for protection or public peace, or from cause of necessity, or expediency, or in a community where the evil of the sales is apparent or experienced, and that not a single proposition for the policy of prohibition arises from demand for relief, sound like Rev. Jasper's declarations: "The Sun he do move; the Earth he do stand still."

The admission that "if laws preventing the sale of liquors should be demanded by the users, and purchasers who desired to be relieved of the temptation of buying it, a wise policy might decree the prevailing of the petition," is followed by a statement that "the non-users and non-purchasers who are in the majority, and those who have never suffered, need protection for which they have not asked." Any careful study will show that a large proportion of the most enthusiastic supporters of prohibitory laws are persons who have either suffered personally or in their families, or socially or financially, from the evils of spirits. Very few persons urge an unpopular cause unless from some strong conviction based on an experience that has a personal bearing. While any new movement always attracts a certain class of irregulars and camp followers, they soon drop out, and seldom continue attached to it very long. The rank and file who are honest in their theories and proposals for relief keep on until their ideals are realized, or some new way gives new form and direction to their efforts.

The earliest liquor law Mr. Morgan could find grew out of some letters appearing in a paper in 1832. At that time there were twenty States in the Union, with a great number and variety of prohibitory laws on their statute books. Many of these States had laws enacted half a century before; even some of the Territories had very stringent laws regulating the liquor traffic. The colony of Georgia for nine years was under a strong prohibitory law passed by the English Parliament in 1735. The early laws prohibiting and restricting the sale of spirits in this country would fill a small-sized volume, even before 1832, and from that time on several volumes would be required to contain them.

The statement that the State of Maine before 1832 was almost

Arcadian in its innocence respecting the use of spirits is remarkable. The laws concerning spirits, local option, license, and prohibition, and the penalties for common drunkards, selling to minors, soldiers, Indians, and drinking on Sunday, and where and when liquors should be sold, passed in 1821–'24 and 1829, give no indications of Arcadian innocence in Maine at that time.

In 1829 the first local option and literal prohibition law was passed in Maine; this was changed from time to time, and finally became the famous Maine law of 1846 and 1851, which exists to-day. In a little volume by Dr. Jewett, published in 1853, appear some harrowing accounts of the crimes and pauperism in Maine springing directly from drunkenness, long before the famous prohibitory law was enacted. Thus there is no doubt that the early settlers of Maine were as much addicted to the so-called vices of drink as any other people.

The author declares that all prohibitory liquor laws are dangerous to the physical, moral, and political health of the community; that (1) "they increase the demand for, while deteriorating the quality of, the supply of liquors." The censuses of 1880 and 1890, and internal revenue reports, indicate a decrease in the sale of spirits in all the States where prohibition exists. The demand and consumption of spirits and beer in adjoining States and cities, not under these laws, give no indications of increased sales of spirits which are or may be consumed in these prohibition sections. Individual opinions to the effect that the demand for spirits has increased are not sustained by statistics from reliable sources. The deterioration in the quality of the liquors is found, from numerous analyses by chemists of the various State Boards of Health, to be principally from water. The drugs used for color and flavor are generally innocuous in both effect and quantity. The quality of the liquor depends on the kind of alcohol, which is far more likely to be dangerous in the so-called pure liquors than the cheap combinations of the saloon keeper.

This fact has been studied by the leading chemists of France, in several elaborate reports, in which it appears that the poisons of liquors are due to the formation and combinations of different alcohols, that are due to natural changes, and can only be known to the analytical chemist and inferred by the clinician from a study of the observed effects on the consumer. It has been repeatedly stated by authorities that a large part of the cheap liquors sold are new spirits adulterated with water, and made pleasant by flavoring substances. Hence cheap liquors from low places may be far safer as beverages than old, expensive spirits from the cellars and vaults of the most reliable dealers.

(2) The assertion that the law against the use of liquors stimulates to greater violation of the law, and produces an appe-

tite for liquor-drinking where it did not exist before, would be easily verifiable if true; but, upon appeal to the facts of statistical reports of criminal and health boards, there is no evidence to sustain it.

The next assertion (3), that such laws give the visionary and crank class in the community political balance of power, is equally unverifiable. The author's complaint that prohibition laws beget an exaggerated oratory, and an appetite for sweeping statements and the cultivation of false statistics, etc., receives a most practical illustration in his paper. His own sweeping denials and allegations of facts, which are not substantiated by any investigation, are ample proof of the danger of such literature to the credulous and unthinking.

To say that all prohibition laws are worse than useless, that they have not lessened the sale or consumption of liquors; that free spirits and free sale would increase the horror of the drunkard and decrease the horror of liquor; and by making the one a crime and nuisance, the merits of the other would come into prominence, or, in other words, increase the severity of the punishment of the drunkard and make the sale of liquor practically free, sounds very tropical to say the least.

The final reference to statistics showing an increased longevity of the drinkers over the total abstainers, as a fact which appeared in the British Medical Journal, is notoriously untrue and mischievous.

Such are some of the allegations which challenge the author for particulars and specifications, to make good his assertions. As they are presented in a historic form, they are apparently based on defective knowledge and incorrect statements and faulty observations of facts, or the construction of facts, according to some theory or purpose, irrespective of all relations or inferences.

It would seem useless to make any detailed study of statements that are unverifiable even if true, in which no appeal to facts is made, especially statements that will not bear the most casual scrutiny. Reformers and their opponents who battle with each other in a "Donnybrook-fair style," striking in all directions, with the wildest dogmatic assertions, reckless of history, facts, and truth, never advance any cause however meritorious.

If the prohibitionary laws are dangerous and injurious there should be facts and data to prove it clearly, and no arguments based on assumed facts, with crooked deductions and doubtful statements, should ever be urged in its defense.

Leaving Mr. Morgan's strange statements, we turn to some general considerations of the alcoholic evil, and the legislative efforts to check and remove it.

To any one who will examine from the scientific side the vari-

ous questions concerning the drink problem, and the remedies offered, many new facts and conclusions will appear. From this point of view, the accumulation of facts and their comparative accuracy is required, with indifference concerning any possible conclusions they may indicate. Wherever personal feelings and self-interest enter into such inquiry, the value and accuracy of the results are impaired. As in a law court, the question is simply one of *facts* and their *meaning*. Some of the facts may be grouped and studied!

In a general way it may be stated that the physiological action of alcohol on the body is practically unknown. Theories of its value as a food, as a nutrient, and as a force-producer, and its usefulness as a beverage, when examined, are found to be unverifiable or untrue. Evidence of its value in health and in moderation rests on theory and superstition, and is not sustained by appeals to facts.

The question of its value as a medicine is by no means settled. Men eminent in science, and fully competent to decide, express doubt, or deny its value altogether. Leading physicians and teachers of medicine prescribe less and less spirits, and the extent of its use in disease is becoming more limited every year.

The evidence of its value as a beverage is doubtful, to say the least, while the disastrous effects of alcohol can not be questioned, and the accumulated evidence of years brings this fact into increasing prominence.

A historical retrospect of the legal efforts to control and restrict the use of spirits suggests an evolution and growth that has not been considered before. Outside of biblical literature, whose teachings and laws are so often quoted, a remarkable chapter of legal enactments and restrictions can be traced. Beginning with the fragmentary inscriptions found on Egyptian papyri and monuments, and extending to the codes, philosophies, and enactments of the greatest philosophers, rulers, and judges of Grecian and Roman civilization, there is a continuous record of prohibitory laws and restrictions concerning the use of spirits and drunkenness. The laws of the Spartans were far more absolute than any modern enactments, and were also remarkable for the clear comprehension of the nature of spirits and their action on the body. These laws were active for many years, and were highly commended.

English history contains many records of prohibitory, restrictive laws, some of which were very prominent for a time, then fell into disuse. Laws of similar import have followed the path of civilization from the earliest dawn and wherever spirits have been used. They have been urged and defended by the greatest philosophers, teachers, and leaders of civilization.

Prohibitory laws and enactments in this country are a repetition of the reform efforts of centuries ago, only on a higher plane, showing decided evolution and growth. The laws of those early times were based on observation of the ill effects of spirits, and the expediency of checking these evils. The same laws in modern times are founded on moral theories and facts which seem to indicate no other means for relief.

In all times the sanitary evils of drink have been recognized at first only faintly, then in an increasing ratio, down to the present. To-day scientists and sanitarians are beginning to understand the perilous and dangerous influence of alcohol in nearly all conditions of life.

Modern prohibitory laws appear to be founded on mixed theories, and are not clear or harmonious in their workings. The applications of these laws, from the earliest settlements of the country down to the present time, give abundant illustrations of this. In several States prohibitory laws have been on trial for a quarter of a century and more, and have seemed to meet the expectations of their supporters. In others such enactments have been abandoned after a short experiment for various complicating reasons. Political partisanship has been so intimately concerned with these questions that the facts are very obscure.

The assertions and denials of the practical value of prohibitory enactments are equally confusing. The only unbiased authority from the census and internal revenue reports, in the states where these laws are in force, points to a diminishing use of spirits, better social and sanitary conditions, and lessened lawlessness.

Widely different explanations of this fact are urged and defended with great positiveness. High license and local option have their warm defenders and bitter opponents. Their value in different communities rests on the same uncertain and differently explained facts; often their adoption or rejection is mere caprice, political selfishness, and the changing sentiment of the hour.

The theoretical scientific study of spirits and their effects opens up another field that brings a wider conception to the problem. Here the student is confronted with the same evidence of evolution. Theories urged two thousand years ago—that drunkenness was a disease, and that spirits was an exciting cause, in some cases merely exploding a condition which was due to influences more remote and widely varied, or building up a morbid state which will require the narcotism of spirits ever after—have become demonstrable facts of modern times.

The remedies for these are restraint, control, and medical treatment of the victims, by legal enactments prohibitory and coercive. It is also evident that vast ranges of unknown causes and

conditions, which enter into the phenomena of life and living, are the basal factors of drunkenness and inebriety. Remedies—legislative, social, and medical—to be effectual must be founded on some general knowledge of these causes. Such are some of the general facts of the drink problem as seen to-day. Many of them are very significant, and have a meaning which is unmistakable.

The great revolutions of theories concerning alcohol and its physiological action on the body, together with the rapid accumulation of evidence contradicting all previous conceptions of its value as a nutrient, stimulant, and beverage, are conclusive that the facts are not all known. Countries and cities where wine and beer and other alcoholic drinks have been used freely, without question, are invaded by temperance and total abstinence societies. Theories of the value of spirits that have come down unquestioned are being challenged and proof of their truth demanded.

The French National Temperance Society, the Society against the Abuses of Alcohol for the Rhine Provinces, the Belgian Total Abstinence Society, the Netherland Society, the Swiss Society, the Italian Society, the Austrian and Prussian Society, the Norwegian, Russian, Danish, and numerous other societies, are urging total abstinence theories, and denying the value of spirits in the very centers of all spirit-drinking countries. Four international congresses have been held in these countries during the past ten years, in which eminent medical men have presented and defended the total abstinence side of the drink problem.

The real facts, separated from all partisan sensationalism, agree that alcohol is a poison, a paralyzant, and narcotic, and its defenders admit this as true, but only in large and reckless quantities. The question then turns on what quantities are safe or dangerous, and what is the possible amount that can be taken within health limits. This is similar to drawing boundary lines between twilight and darkness, and is obviously impossible with the present limits of our knowledge.

The evidence up to this time from the chemical laboratory, from experiments, from hospital studies, from statistics, and other sources, clearly proves that alcohol is a poison and is positively dangerous to health—in what way, in what conditions, and under what circumstances is yet an open question, in which difference of opinion will exist until more exhaustive experimental studies are made. Text-books for schools and colleges and partisan discussions often contain statements conveying the misleading impression that the facts about alcohol are known, when, in reality, beyond a few general principles, we are profoundly ignorant of its physiological action. The facts concerning its ravages and baneful influence are too common to be called in question,

and the statement that it is the greatest peril to modern civilization has a basis in actual experience.

It appears to be a conclusion, which all scientific and sociological progress is verifying, that a more complete knowledge of alcohol will demand some form of prohibitory laws; whether like those existing at present or not it is impossible now to say. Such laws will not depend on any sentiment or any theory, but will be founded on demonstrated truths, and the necessity for self-preservation. It will not be a question of Maine law, or whether prohibition prohibits, or whether any party or society or public sentiment favors or opposes it. Action will be taken on the same principle that a foul water supply is cleansed or a sanitary nuisance removed. The questions of high or low license, local option, and all the various schemes of partial or complete restriction, with the vast machinery of moral forces that seek relief by the church, the pledge, the prayer, and the temperance society, will be forgotten, and the evil will be dealt with in the summary way in which enlightened communities deal with other ascertained causes of dangerous disease.

While the average citizen may be slow to unlearn and change his views about alcohol, he is ever quick to recognize and provide for dangers that peril his personal interests. Show this man that every place where spirits are sold as a beverage is a "poison center" and every drinker is a suicidal maniac, whose presence is dangerous to the happiness and peace of the community, and he will at once become a practical prohibitionist. This is the direction toward which all temperance agitation is drifting.

Sanitary boards, government commissions, and hospital authorities must gather the facts from very wide sources, and the generalizations from these will supplement and sustain the laboratory and hospital work and point out conclusions that will be real advances in this field. Inebriate asylums (at present obscure and bitterly opposed) will become very important aids in the study of the causes of inebriety. Like prohibitory laws, they will become a recognized necessity when the disease of inebriety and the poison of alcohol are understood.

Beyond all theory and agitation there is another movement of startling significance. Everywhere the moderate and excessive drinking man is looked upon with suspicion. His capacity is doubted, and his weakness is recognized as dangerous in all positions of trust and confidence. Corporations and companies demand employees to be total abstainers. Railroads, manufactories, and even retail liquor dealers of the better class require all workmen to be temperate men. This is extending to all occupations, and the moderate drinker is being crowded out as dangerous and unfit. This movement has no sentiment, but is the result of experi-

ence and the recognition of the danger of the use of alcohol as a beverage. Nothing can be more absolute than these unwritten prohibitory laws which discharge workmen seen in saloons and refuse to employ skilled men because they use spirits in moderation.

To repeal all restrictive and prohibitory laws and open the doors for the free use of rum is to act in opposition to all the facts of observation and experience. On the other hand, to insist that prohibitory laws are the only measures to correct the drink evils, or that high license and local option are equally powerful as remedies, is to assume a knowledge of alcohol and inebriety that has not been attained. The highest wisdom of to-day demands the facts and reasons for the use of alcohol, and why it should be literally and theoretically the cause of so much loss and peril to the race. All hope for the future solution of these questions must come from accurately observed facts and their teachings, and, like the problems of the stars above us, be determined along lines of scientific inquiry.

DAIRY SCHOOLS AND DAIRY PRODUCTS.

By F. W. WOLL,

ASSISTANT PROFESSOR OF AGRICULTURAL CHEMISTRY IN THE UNIVERSITY OF WISCONSIN.

EVERYBODY likes good butter and good cheese, but to a large proportion of our population these very desirable articles of food would come in under the head of luxuries. Perhaps more than ninety per cent of the butter consumed by our people is made on farms or in private dairies; a great deal of it is fit for a king's table, and more and more of this kind of butter is made every year; still, when we consider the number of small towns in the United States and the quality of the mass of butter which every week is brought to the corner grocery store in each one of these places, there to be exchanged for three cent calico or twenty-five-cent coffee, it is evident that a large proportion of our butter is unqualifiedly bad. As for much of the cheese sold, the trouble lies in another direction—less in faulty methods of manufacture than in a flooding of the market with an immature, indigestible, sole-leather product, which some of us may know from the dining rooms of second and third class hotels.

While we, therefore, may find fault with a large share of the dairy products sold in the United States, we can not wonder very much that such is the case. Not until of late years has thorough, systematic instruction in their manufacture been offered anywhere in this country. The fundamental principles of the

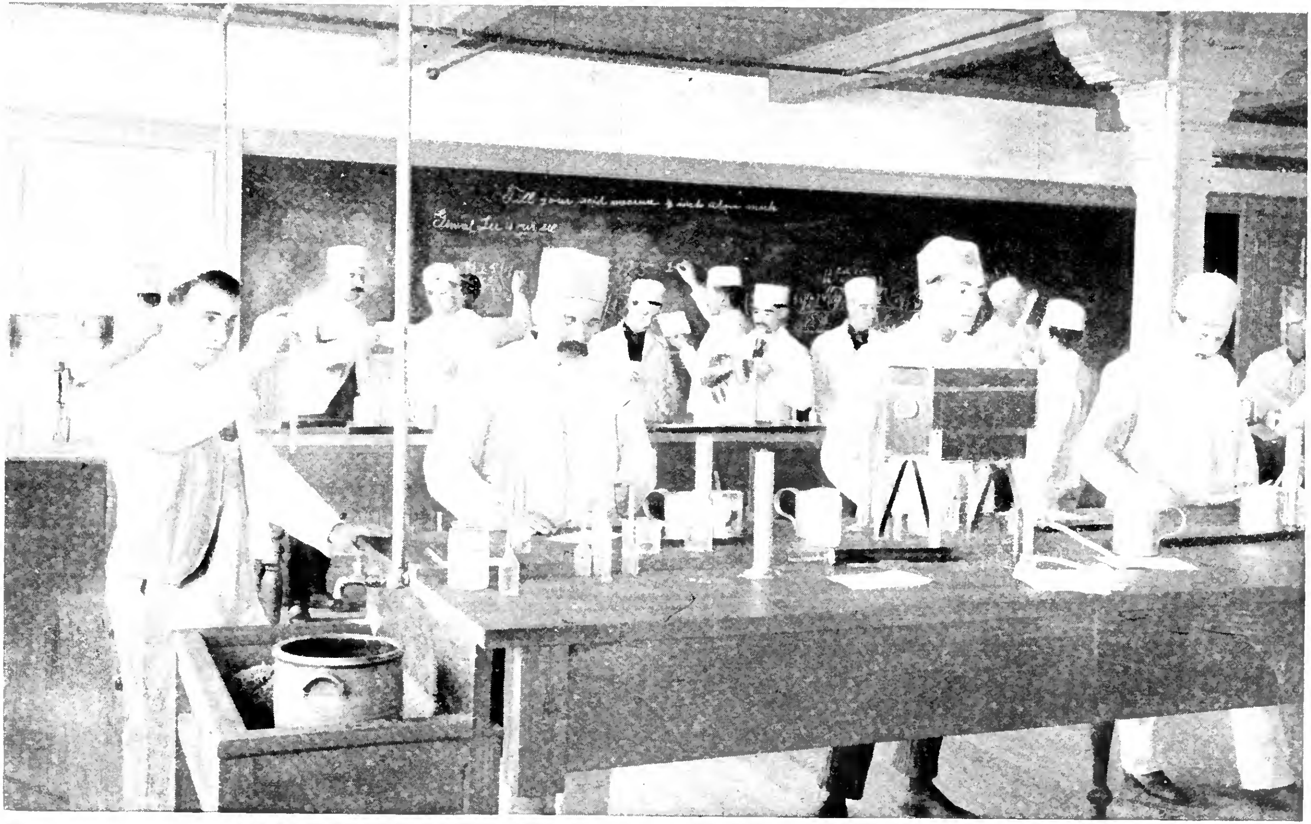


Fig. 1.—View of Milk-testing Laboratory, Wisconsin Dairy School.

handling and care of milk and cream, and of the cream and butter in and out of the churn, are almost unknown to thousands of butter-makers, and more especially to the private, non-professional ones among these, who are in the great majority. The engineers have their mechanical colleges and their schools of technology, the doctors have their medical schools, and the druggists their pharmacy colleges, but the dairy farmers have had practically no place where they could receive instruction in the theory and practice of butter and cheese making. I am aware that there have been agricultural colleges in the United States since 1855, but as far as practical instruction in dairying is concerned a good many of them might as well not have existed at all, if I do not radically misjudge the situation. Lectures in dairying, in which the principles of butter-making were to be taught, were certainly included in the curricula of some of the colleges, under the charge of the Professor of Agriculture, but this gentleman most likely also had charge of the feeding and breeding of farm animals, cultivation of crops, soil physics, farm management, and other studies. It is not strange that the attention given to dairy matters and to the manufacture of dairy products could only be very scant under these conditions. There were so many important problems to be taken up and discussed in relation to general agricultural topics that time would not permit entering into details, even if the professor had the inclination to do so.

This state of affairs led to the establishment of separate schools for instruction in dairying, especially in the manufacture of butter and cheese. Such schools have existed in Europe for a number of years; here they were not introduced until four years ago, when the Wisconsin Dairy School was founded as a separate department of the Agricultural College of the University of Wisconsin. So spontaneous was the growth of this school, and so rapid the adoption of the system in many other States of the Union, that it surprised the most ardent supporters of the movement.

The Wisconsin Dairy School dates from January, 1890, when a short dairy course was arranged for students taking the winter course in the College of Agriculture; two out of the twenty-seven agricultural students took this dairy course. The following year, when the course was greatly widened and the dairy school proper organized, seventy-two students entered, crowding the quarters of the school to the very utmost. The Wisconsin Legislature having in 1891 appropriated twenty-five thousand dollars for a separate dairy-school building, the work was at once pushed forward; where a crop of corn was taken off the ground in September, 1891, a neat, substantial edifice was erected, the first story of which was ready for occupancy in January, 1892, and in March the first class

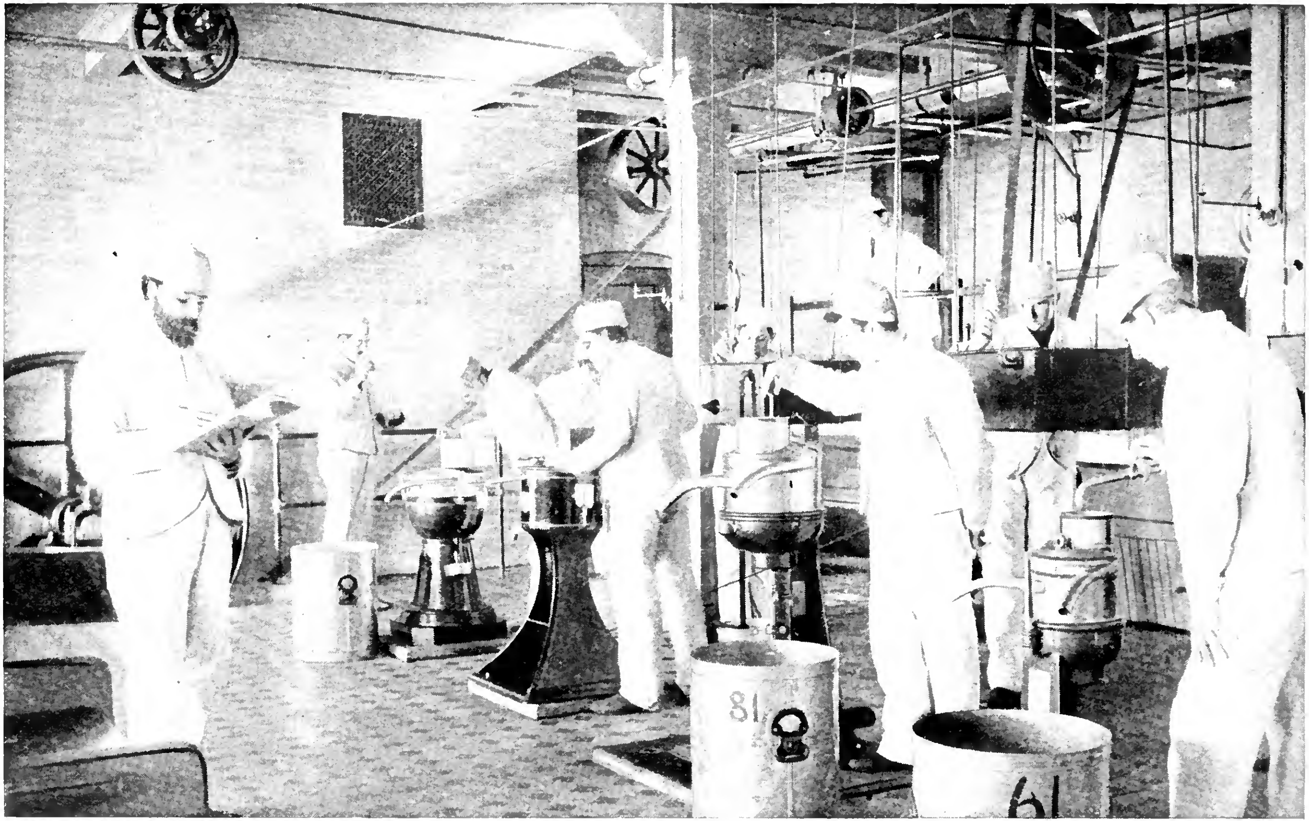


Fig. 2.—View of Separator Room.

of students from the new dairy school was graduated, thus securing for the university two crops from the same land within a year. The building was finished during the summer of 1892, and is a model in appearance and equipment. Its cost up to date with equipment amounts to nearly forty thousand dollars. The name of the building, Hiram Smith Hall, was given it in honor of the veteran Wisconsin dairyman, Hon. Hiram Smith (1890), for twelve years a regent of the University and chairman of the Farm Committee of the Board of Regents, to whose enthusiasm and untiring efforts the school largely owes its existence. The building is calculated to accommodate one hundred students, and this number was reached the first year. Last year one hundred candidates applied for admission before December 1st, although the school did not begin until January 4th, and later applicants had to be turned away. Students have come from Canada and almost every State in the Union where dairying is a leading industry: Minnesota, Illinois, and Michigan have furnished their quota; so have Maine and California; New Hampshire and Nevada; New York, Indiana, Iowa, Missouri, and Kansas.

We can not here enter into a detailed description of the courses of instruction offered in the school, but a short outline of the same will be given. Only branches bearing directly on the science and practice of dairying and on the manufacture of dairy products are taught. The policy of the governing board is to make the instruction thoroughly practical; at the same time the theoretical side is considered no less important. The professors and instructors connected with the school are specialists in their various branches; the instructors in the cheese room and the creamery are expert cheese and butter makers.

The instruction is given, first, by lectures; second, by work at the separators, the churns, and the cheese vats, as well as in the laboratory. Lectures are given in the following branches: The breeds and breeding of dairy cows, the feeding of dairy cows, diseases of dairy cows, the chemistry of milk and its products, bacteriology of the dairy products, physical problems connected with the dairy, and the care and management of the boiler and engine. These subjects are presented to the class by different professors of the university.

The practical work is taught in the butter and cheese room, as well as in the laboratory. The picture of the separating room shows the arrangement of the separators. Of these all the latest and most improved patterns are kept, as well as of the butter extractor. It may be in order to state, for the benefit of the many readers who never were inside of a creamery or a farm dairy, that a cream separator or a *centrifuge*, as it is sometimes called, is a machine for separating the cream from the skim milk by means of

centrifugal force. A strong steel bowl is made to rotate by hand-power or steam, at a speed of five to eight thousand revolutions per minute; by this means the heavier portion of the milk, the skim milk, is separated from the lighter portion, the cream, and both are collected in separate vessels.

The work in the creamery room includes the handling and care of the cream previous to churning, the churning, and the working and packing of the butter. In the cheese room, where there are eight milk vats, each of a capacity of three hundred pounds, thirty-two students may work at the same time; the various steps in cheese-making, from the proper handling of the milk to the curing of the cheese, are here learned.

A most important part of the instruction is the milk testing, which is taught in the laboratory. Farmers' boys, who previously to their entering the school knew nothing whatever about the different components of milk, here learn to determine the percentage of fat in milk, skim milk, buttermilk, whey, and cream, with almost as great accuracy as any experienced chemist, and certainly as satisfactorily for all practical purposes. This has been made possible by the introduction of the Babcock test for the determination of fat in milk, a method invented nearly four years ago by Dr. S. M. Babcock, chief chemist to the Wisconsin Experiment Station. The method has won for its originator a world-wide reputation and the gratitude of progressive dairy farmers in this and other countries. The test, which was given to the public without any restriction of patent, is extremely simple, and may be made on a farm or in a creamery or cheese factory as well as in a chemical laboratory, everywhere with equal correctness and facility. In the dairy school the percentage of fat in milk is determined by Babcock's test, and by a combination of the test and the lactometer (a simple apparatus to determine the specific gravity of milk or its weight in relation to water), adulteration of the milk, and the extent of the same may be detected.

The course of the dairy school lasts three months—viz., January to March, inclusive. The expenses of the school while in operation are very heavy; the milk bill alone thus amounts to eighty dollars a day during this time. In addition to this course, dairy certificates are issued to such graduates of the school as have shown proficiency in the operation of a creamery or a cheese factory for one or more seasons; candidates for such certificates must send in reports of their work once a month to the dean of the college; their factories are further inspected by an instructor of the school, to ascertain whether or not the candidate may be granted a certificate, and thereby given the recommendation of the State Dairy School as a successful butter or cheese maker.

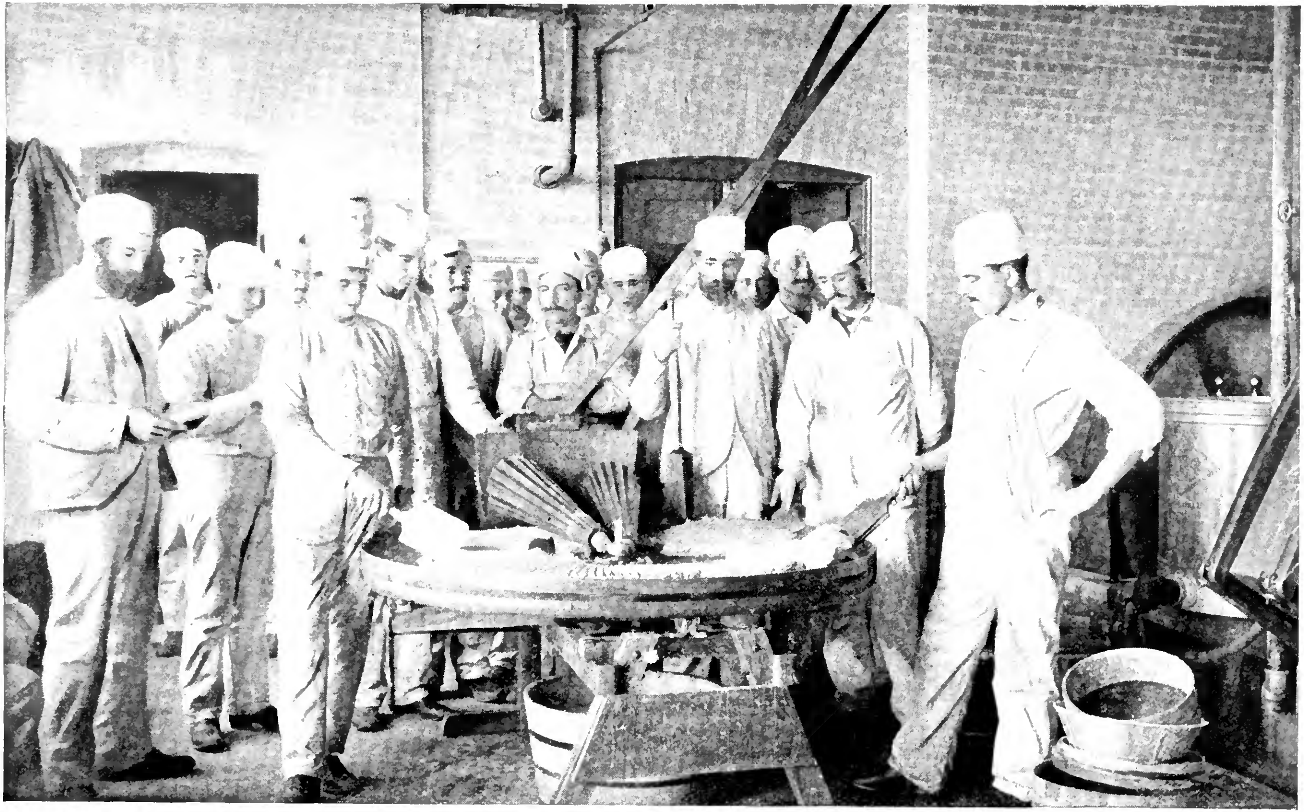


Fig. 3.—Students at the Butter Worker.

Dairy schools on a similar plan as the one just described have been in operation during the past year or two at the Agricultural Colleges of Minnesota, Pennsylvania, Vermont, Iowa, and New York (Cornell). Other States will doubtless establish similar schools in the near future, as the demand for instruction in these branches is steadily increasing, and students are taxing to the utmost the capacity of the schools existing.

Only a small proportion of the milk produced in the United States is obtained on farms situated in the direct neighborhood of cities where the milk can be sold as such; in all other places it must be manufactured into butter or cheese. Where the population of a district is not sufficient to support a butter or cheese factory, the manufacture of dairy products, and primarily butter, must take place on the farm itself. Modern invention has greatly facilitated the work of butter-making on the farm; by the introduction of hand separators all apparatus for setting the milk, either in ice tanks or in a separate milk room, in metal or wooden vessels, may be done away with; the cream is obtained at once by the separator, and thus only one fifth of the quantity of material has to be taken care of, as the skim milk may be fed directly to calves or pigs. These hand separators are made in various sizes to suit the requirements of different herds. They are not very expensive, so that any farmer of moderate means can buy them. The manufacturers claim for them, and without exaggeration, that they will pay their cost each year over and above any other system, with a herd of ten or more cows, on account of the larger yield of butter obtained with them from the same quantity of milk. In other systems of creaming a much larger portion of the fat in the milk is left in the skim milk, which is thus lost for butter-making.

The modern churns, which are mostly barrel-shaped or of rectangular form, make churning mere play. The method of butter-making now generally adopted is about as follows: The cream is churned at about 56° to 62° Fahr., the temperature differing somewhat with the season and the ripeness of the cream. The butter will come after twenty to forty minutes' turning, sometimes more, sometimes less, according to acidity, temperature, and other conditions present. The buttermilk is then drawn off through a hole near the bottom of the churn, and the butter washed in the churn, placed on the butter worker to free it as completely as possible from buttermilk, and then salted (one ounce of salt to one pound of butter); again worked and packed in tubs, and is now ready for shipment. Our pictures show the making of creamery and of dairy butter.

In this country cheese is made almost entirely in factories; as many will know, the process employed in the making of our ordi-

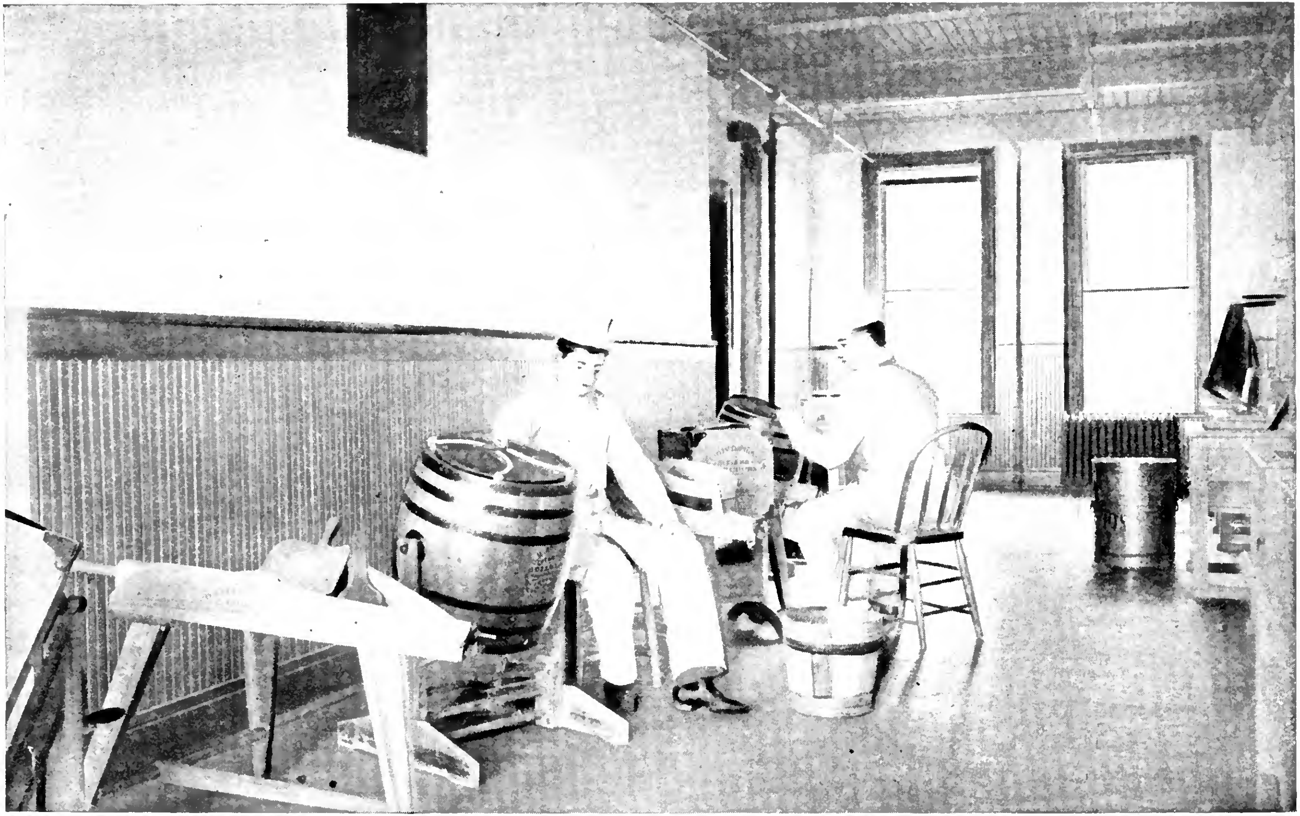


Fig. 4.—Butter-making Apparatus for Small Dairies.

nary Cheddar cheese is as follows: The milk is heated to 86° Fahr., in the cheese vat; one to four ounces of rennet extract is then added, according to the kind of cheese desired. The rennet coagulates the milk in less than half an hour; when the curd is firm, it is cut into small cubes by means of cheese knives, and heated slowly to 98° Fahr.; after about two hours the whey is ready to be drained off, the curd put on racks, and various operations gone through, of no special interest to the general reader; it is then salted (two to three pounds of salt to one thousand pounds of milk containing four per cent fat), put in hoops and pressed for twenty-four hours, and finally placed in the curing room. The more rennet is added to the milk, the quicker the cheese will cure; the more salt, the slower it will cure. Cheddar cheese ought to cure at least two months before it is put on the market, but is often sold only a couple of weeks old.

I have barely touched upon the main features in the manufacture of dairy products in the preceding. While it does not take very long to learn the important steps in their manufacture, it requires good common sense and thorough knowledge of the composition and properties of dairy products and the many conditions affecting the various processes, in order to become a successful butter or cheese maker. No cast-iron rules can be laid down in most cases, and no man can therefore make the kind of butter and cheese that you and I like, unless he understands his work thoroughly and uses good judgment in the discharge of his duties.

The dairy industry of the United States can not help receiving a grand impetus through the agency of the dairy schools; the quantity of dairy products will be increased through a better selection of animals, through more liberal, systematic feeding and better care being taken of them, and the quality of the products will be improved by a thorough understanding of the theory and practice of their manufacture. The magnitude of our dairy industry makes this educational work a most important one. The value of the annual product of butter and cheese made on farms or in factories in the United States in 1880, according to the tenth census, amounted to nearly one hundred and forty million dollars. More than eight hundred million pounds of butter and two hundred and forty million pounds of cheese were made during 1880. When it is remembered that the average annual yield of butter per cow in the United States does not exceed one hundred and twenty-five pounds, while single herds give three and even four hundred pounds a year per cow—when, furthermore, the mass of butter sells at an average of less than fifteen cents a pound, while private parties obtain fifty cents or more a pound for their butter—then we understand what a grand opportunity is offered to

educators for missionary work in this line. This work our dairy schools, agricultural experiment stations, dairymen's associations, and similar organizations are doing, and American dairying is rapidly progressing toward a higher standard through their agencies.

THE ICE AGE AND ITS WORK.

By ALFRED R. WALLACE, F. R. S.

EROSION OF LAKE BASINS.—(*Continued.*)

IV.

THERE is really only one alternative theory to that of ice erosion for the origin of the class of lakes we have been discussing, viz., that they were formed before the Glacial epoch, by earth movements of the same nature as those which are concerned in mountain formation, that is, by lateral pressure causing folds or flexures of the surface; and where such flexures occurred across a valley a lake would be the result. This is Prof. Bonney's theory given in his paper in the Geographical Journal, and it is also that of Desor, Forel, Favre, and other eminent geologists. It is explained fully in the work of M. Falsan (already quoted), who also adopts it; and it may be considered, therefore, that if this theory can be shown to be untenable that of glacial erosion will hold the field, since there is no other that can seriously compete with it. Prof. Bonney considers this theory completely satisfactory, and he complains that the advocates of glacial erosion have never discussed it, intimating that they "deemed silence on this topic more prudent than speech."

As this theory is put forward with so much confidence, and by geologists of such high reputation, I feel bound to devote some space to its consideration, and shall, I think, be able to show that it breaks down on close examination.

In the first place, it does not attempt to explain that wonderful absence of valley lakes from all the mountain regions of the world, except those which have been highly glaciated. It is, no doubt, true that during the time the lakes were filled with ice instead of water, they would be preserved from filling up by the influx of sediment; and this may be fairly claimed as a reason why lakes of this class should be somewhat more numerous in glaciated regions, but it does not in any way explain their total absence elsewhere. We are asked to believe that in the period immediately preceding the Glacial epoch—say, in the Newer Pliocene period—earth movements of a nature to produce deep lakes occurred in every mountain range without exception that was

about to be subject to severe glaciation, and not only so, but occurred on both sides of each range, as in the Alps, or all round a mountain range, as in our lake district, or in every part of a complex mountain region, as in Scotland from the Frith of Clyde to the extreme north coast—all in this very limited period of geological time. We are further asked to believe that during the whole period from the commencement of the Ice age to our day such earth movements have never produced a single group of valley lakes in any one of the countless mountain ranges and hilly regions throughout the whole of the very much more extensive non-glaciated regions of the globe! This appears to me to be simply incredible. The only way to get over the difficulty is to suppose that earth movements of this nature occurred only at that one period, just before the Ice age came on, and that the lakes produced by them in all other regions have since been filled up. But is there any evidence of this? And is it probable that *all* lakes so produced in non-glaciated regions, however large and deep they might be, and however little sediment was carried down by their inflowing streams, should yet all have disappeared? The theory of the pre-glacial origin of these lakes thus rests upon a series of highly improbable suppositions entirely unsupported by any appeal to facts. There is, however, another difficulty which is perhaps even greater than those just considered. Whatever may be the causes of the compression, elevation, folding, and other earth movements which have led to the formation of mountain masses, there can be no doubt that they have operated with extreme slowness; and all the evidence we have of surface movements now going on show that they are so slow as to be detected only by careful and long-continued observations. On the other hand, the action of rivers in cutting down rocky barriers is comparatively rapid, especially when, as in all mountainous countries, they carry in their waters large quantities of sediment, and during floods bring down also abundance of sand, gravel, and large stones. A remarkable illustration of this erosive power is afforded by the river Simeto, in Sicily, which has cut a channel through solid lava which was formed by an eruption in the year 1603. In 1828, Sir Charles Lyell states, it had cut a ravine through this compact blue rock from fifty to several hundred feet wide, and in some parts from forty to fifty feet deep.* The enormous cañon of the Colorado, from three thousand to five thousand feet deep and four hundred miles long, which has been entirely cut through a series of Mesozoic and Palæozoic rocks during the latter portion of the Tertiary period, is another example of the wonderful cutting power of running water.

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* Principles of Geology, eleventh ed., vol. i, p. 353.

It is, in fact, only on account of this powerful agency that we do not find valley lakes abounding in every mountainous country, since it is quite certain that earth movements of various kinds must have been continually taking place. But if rivers have always been able to keep their channels clear, during such movements, among the mountains of the tropics and of all warm countries, some reason must be found for their inability to do so in the Alps and in Scotland, in Cumberland, Wales, and southern New Zealand; and as no reason is alleged, or any proof offered, that sufficiently rapid and extensive earth movements actually did occur in the subalpine valleys of these countries, we must decline to accept such a hypothetical and unsatisfactory explanation.

Nothing is more easy, and nothing seems at first sight more plausible, than to allege these "earth movements" to account for any one lake whose origin may be under discussion. But it ceases to be either easy or plausible when we consider the great number of the lakes to be accounted for, their remarkable positions and groupings, and their great depths. We must postulate these movements, all about the same time, in every part of the Highlands of Scotland, everywhere in the Lake district, and on both sides of the Alps. Then, again, the movements must have been of greater extent just where we can prove the glaciation to have been most severe. It produced lakes from one hundred feet to two hundred and seventy feet deep in Cumberland and Westmoreland; in Scotland, where the ice was much thicker, the lakes are from over three hundred to over one thousand feet deep; while in the Alps of Switzerland and North Italy, with its vast glaciers and ice-sheets, many are over one thousand feet, and one reaches the enormous depth of over twenty-five hundred feet. It may be said that the depth is in proportion to the height of the mountains; but in equally high mountains that have not been glaciated there are no lakes, so this can not be the true explanation. One more remarkable coincidence must, however, be pointed out. The two largest Swiss lakes—those of Geneva and Constance—are situated just where the two greatest West European rivers, the Rhone and the Rhine, get beyond the mountain ranges; while on the south, one of the largest and by far the deepest of the lakes—Lake Maggiore—collected into its basin the glacier streams from a hundred miles of the high Alps, extending from Monte Rosa on the west to the peaks above San Bernardino on the east. Throughout this great curve of snowy peaks the streams converge, with an average length of only thirty miles, to unite in a valley only six hundred and forty-six feet above the sea level. No such remarkable concentration of valleys is to be found anywhere else in the Alps, and no other lake reaches to nearly so great a depth. On the theory of glacial erosion we have here cause and effect; on that

of earth movements we have another mere coincidence added to the long series already noticed. The depth of over twenty-five hundred feet undoubtedly seems enormous, but that depth exists just at the point where the two great valleys which have collected the converging streams above referred to unite together. Geologists will probably not think thirty thousand years an extravagant estimate for the duration of the Glacial period, in which case an erosion of only an inch in a year would be sufficient. Lago di Garda, the largest Italian lake, had a still larger catchment area in glacial times but not nearly so much concentrated; hence, perhaps, its comparatively moderate depth of about one thousand feet. We see, then, that on the theory of erosion, the size, depth, and position of the chief lakes are all intelligible, while on that of earth movements they have no meaning whatever, since the deep-seated agencies producing subsidence, upheaval, or curvature of the surface would be as likely to act in the small as in the large valleys, and to produce deep lakes in other places than those where, at a later epoch, the thickest glaciers accumulated.

THE CONTOURS AND OUTLINES OF THE LAKES INDICATE EROSION RATHER THAN SUBMERGENCE.—While collecting facts for the present articles, it occurred to me that the rival theories of lake formation—erosion and submergence—were so different in their modes of action that they ought to produce some marked difference in the result. There must be some criteria by which to distinguish the two modes of origin. Under any system of earth movements a valley bottom will simply become submerged, and be hardly more altered than if it had been converted into a lake by building an artificial dam in a convenient situation. We should find, therefore, merely a submerged valley with all its usual peculiarities. If, however, the lake basin has been formed by glacial erosion, then some of the special valley features will have been destroyed, and we shall have a distinct set of characters which will be tolerably constant in all lakes so formed. Now I find that there are three such criteria by which we ought to be able to distinguish the two classes of lakes, and the application of these tests serves to show that most of the valley lakes of glaciated countries were not formed by submergence.

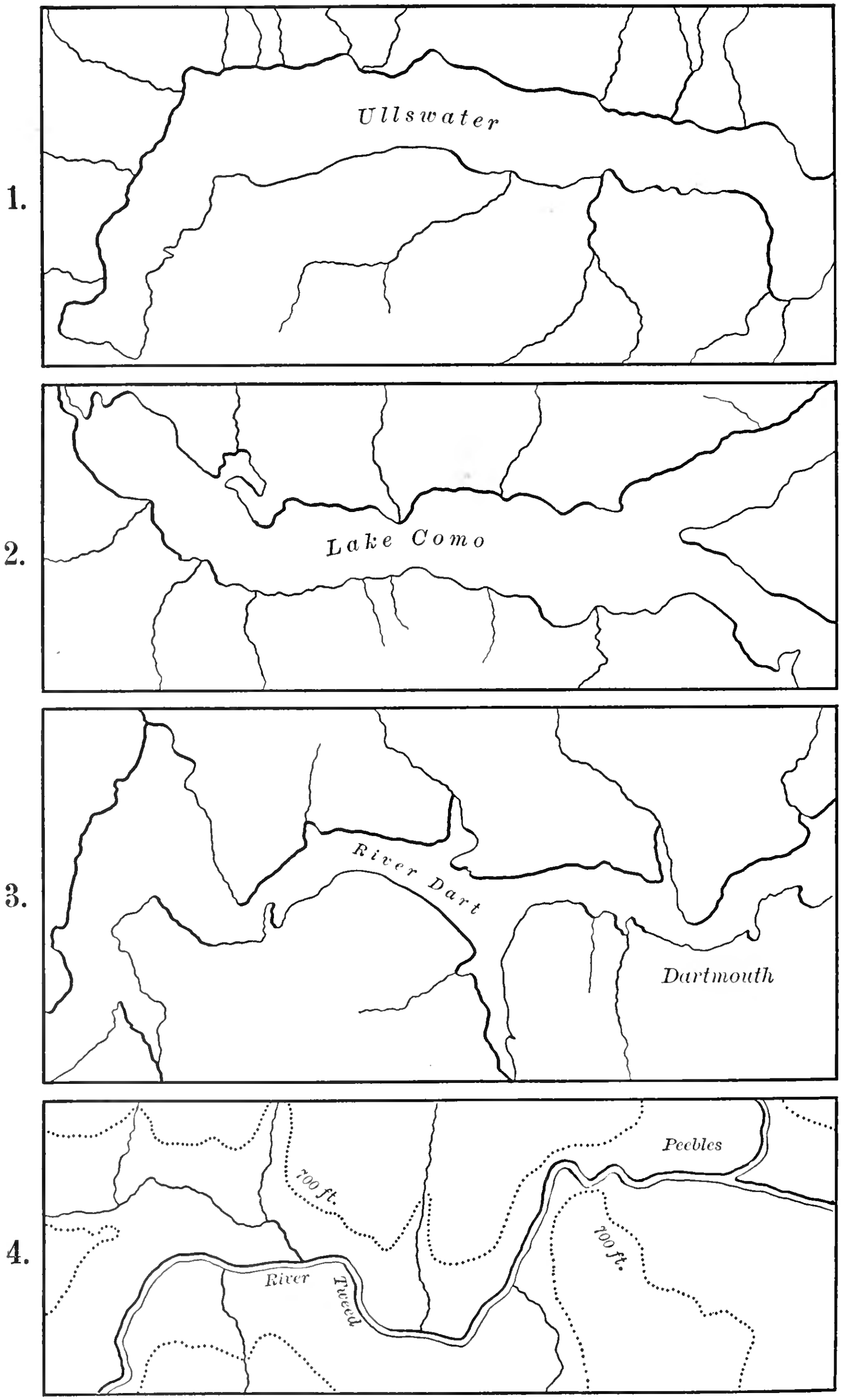
The first point is that valleys in mountainous countries often have the river channel forming a ravine for a few miles, afterward opening out into a flat valley, and then again closing, while at an elevation of a hundred or a few hundred feet, at the level of the top of the ravine, the valley walls slope back on each side, perhaps to be again flanked by precipices. Now, if such a valley were converted into a deep lake by any form of subsidence, these ravines would remain under water and form submerged river

channels. But neither in the lakes which have been surveyed by the Swiss Government, nor in the Atlas des Lacs Françaises of M. Delebecque, nor in those of the German Alps by Dr. Alois Geistbeck, nor in the lakes of our own country, can I find any indications of such submerged river channels or ravines, or any other of the varied rock features that so often occur in valleys. Almost all these lakes present rather steeply sloping sides with broad, rounded, or nearly level bottoms of saucer shape, such as are certainly not characteristic of subaërial valley bottoms, but which are exactly what we might expect as the ultimate result of thousands of years of incessant ice grinding. The point is, not that the lake bottoms may not in a few cases represent the contours of a valley, but that they never present peculiarities of contour which are not unfrequent in mountain valleys, and never show submerged ravines or those jutting rocky promontories which are so common a feature in hilly districts.

The next point is, that Alpine lake bottoms, whether large or small, frequently consist of two or more distinct basins, a feature which could not occur in lakes due to submergence unless there were two or more points of flexure for each depression, a thing highly improbable even in the larger lakes and almost impossible in the smaller. Flexures of almost any degree of curvature are no doubt found in the rocks forming mountain chains; but these flexures have been produced deep down under enormous pressure of overlying strata, whereas the surface beds which are supposed to have been moved to cause lakes are free to take any upward or downward curves, and, as the source of motion is certainly deep-seated, those curves will usually be of very gradual curvature. Yet in the small lake of Annecy there are two separate basins; in Lake Bourget also two; in the small lake of Aiguebellette, in Savoy, there are three distinct basins of very different depths; and in the Lac de St. Point, about four miles long, there are also three separate flat basins. In Switzerland the same phenomenon is often found. In the Lake of Neufchâtel there are three basins separated by ridges from twenty to thirty feet above the deeper parts. The small Lac de Joux, at the head of a high valley in the Jura, has also three shallow basins. Lake Zurich consists of three well-marked basins. The exceedingly irregular Lake of Lucerne, formed by the confluence of many valleys meeting at various angles hemmed in by precipitous mountains, has eight distinct basins, mostly separated by shallows at the narrow openings between opposing mountain ridges. This is exactly what would result from glacier action, the grinding power of which must always be at a maximum in the wider parts of valleys, where the weight of the ice could exert its full force and the motion be least impeded. On the subsidence or curvature

theory, however, there is no reason why the greatest depth should occur in one part rather than in another, while separate basins in the variously diverging arms of one lake seem most improbable. The lakes of Thun and Brienz form two basins of what was evidently once a single lake. The upper or Brienz basin is enormously deep, over two thousand feet, and the reason is obvious. The combined glaciers of the Lauterbrunnen and Grindelwald Valleys entered the main valley in a direction almost opposite to that of the Aare, piling up the ice against the great barrier of the Rieder Grat, so that it at length flowed downward with greatly increased grinding power; while lower down, toward Thun, the valley opens widely and would thus allow the ice to spread out with greatly diminished thickness. In our own country Loch Lomond and Ullswater have been found to consist of several distinct basins, and in none of our lakes have any indications of submerged river channels yet been found.

The third point of difference between lakes of erosion and those of submersion is the most important and the most distinctive, and furnishes, I think, what may be termed a diagnostic character of lakes of erosion. In most river valleys through a hilly or mountainous country outside of the glaciated districts, the tributary streams entering more or less at right angles to the main valley are seen to occupy small valleys of their own, which usually open out for a short distance at the same level before joining the main valley. Of course, there are also torrents which rush down steep mountain slopes directly to the main river, but even these have usually cut ravines more or less deeply into the rock. Now, if in such a valley we could mark out a contour line two hundred, three hundred, or five hundred feet above the level of the main stream, we should see that line continually turning up each side valley or ravine till it reached the given level at which to cross the tributary stream, and then turning back to the main valley. The contour line would thus form a series of notches or loops of greater or less depth at every tributary stream with its entering valley or deeply cut ravine, and if the main valley were filled with water this line would mark out the margin of the lake. As an illustration of this feature we may take the southwest coast of England, which has never been glaciated, but which has undergone a slight recent subsidence, as indicated by the submerged forests which occur at several places. The result of this submergence is that the lower parts of its larger river valleys have been converted into inland tidal lakes, such as Poole Harbor, Dartmouth Harbor, Kingsbridge River, Plymouth and Devonport Harbors, and Carrick Road above Falmouth. The Dart River is an excellent example of such a submerged valley, and its outline at high-water mark is shown at (3) on the accom-



Lake Forms due to Erosion (1, 2); to Submersion (3, 4).

panying cut, where the characteristic outline of such a valley is well indicated, the water running up every tributary stream, as described above. The lower section (4) shows the same feature by means of a map of the river Tweed, near Peebles, with the seven hundred feet contour line marked on it by a dotted line.* If the valley were submerged to this depth the dotted line would mark the outline of a lake, with arms running up every tributary stream just as in the case of the river Dart. Although situated in a glaciated district the valley here is post-glacial, all the old river channels being deeply buried in drift.

If we now turn to the valley lakes in glaciated districts we shall find that they have a very different contour, as shown by the two upper outline maps on the same page: (1) showing the upper part of Ullswater on a scale of one mile to an inch, as in the Dart and Tweed maps; and (2) showing the upper part of Lake Como, taken from the Alpine Club map, on a scale of four miles to an inch. In both of these it will be seen that the water never forms inlets up the inflowing streams, but all of these without exception form an even junction with the lake margin, just as they would do if flowing into a river. Exactly the same feature is present in the lower portions of these two lakes, and it is equally a characteristic of every lake in the Lake district, and of all the Swiss and Italian lakes. On looking at the maps of any of these lakes one can not but see that the lake *surface*, not the lake *bottom*, represents approximately the level of the pre-glacial valley, and that the lateral streams and torrents enter the lake in the way they do because they could only erode their channels down to the level of the old valley before the ice overwhelmed it. Of course, this rule does not apply to large tributary valleys carrying separate glaciers, since these would be eroded by the ice almost as deeply as the main valley.

The three features of the valley lakes of glaciated regions now pointed out—the absence of submerged ravines or river channels either of the main river or of tributary streams; the basin forms of the lake bottoms and the frequent occurrence of two or more separate basins even in small lakes; and the simple form of surface contour of all this class of lakes, so strongly contrasting with that of valleys known to have been recently submerged, as well as with the contour lines of valleys in non-glaciated districts and in those which are known to be post-glacial—seem to afford, as nearly as the case admits, a demonstration that the lakes presenting these features have been formed by erosion and not by submergence.

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* Copied from a portion of the map at page 144 of Geikie's Great Ice Age, taken from the Ordnance Survey Map.

In connection with this subject may be noticed the many cases in which Alpine valleys present indications of having been greatly deepened by glacial erosion, although, owing either to the slope of the ground or the uniformity of the ice action, no lake has been produced. In some valleys, as in that of Lauterbrunnen, the trough between the vertical rock walls was probably partly formed before the Ice age, but was greatly deepened by glacial erosion, the result being that the tributary streams have not since had time to evacuate ravines of equal depth with the main valley, and therefore form a series of cascades over the lateral precipices, of which the Staubbach is the finest example. In many other cases, however, the side streams have cut wonderfully narrow gorges by which they enter the main vally. This work was probably begun by a subglacial stream, and the action of the atmosphere being shut out by the superincumbent ice and all variation of temperature avoided, the torrent cut for itself a very narrow groove, sometimes with overhanging sides, as it found layers of somewhat softer rock to eat away; and the upper surface of the rock being ground smooth by the ice, the atmosphere has had little effect since, and the gorge, while deepened below, has remained as restricted above as when first eroded. Such are the gorges of the Trient, Leuk, Pfäffers, and many others well known to Alpine tourists. I am not aware whether such extremely narrow winding gorges, often only two or three feet between the rock walls, are to be found in countries which have never been glaciated. I do not myself remember reading of any, though, of course, tremendously deep ravines are common, but these are of quite a different character. Should it be found that these extremely narrow rock-walled gorges are peculiar to glaciated districts they will afford us a means of estimating the amount of glacial erosion in valleys where no lake basins have been formed.

THE LAKE OF GENEVA AS A TEST OF THE RIVAL THEORIES.—When I recently began to study this question anew, I was inclined to think that the largest and deepest of the Alpine lakes, such as Geneva, Constance, Lago Maggiore, and Lago di Garda, might perhaps have originated from a combination of earth movements with ice erosion. But on further consideration it appears that all the characteristic features of erosion are present in these as fully as in the smaller lakes. They are situated in the largest river valleys or in positions of greatest concentration of the glacier streams; their contours and outlines are those of eroded basins; while all the difficulties in the way of an origin by earth movements are as prominent in their case as in that of any other of the lakes. I will therefore discuss, first, some of the chief objections to the erosion theory as applied to the above-named lake,

and then consider the only alternative theory that has obtained the acceptance of modern writers.

One of the first objections made was, that the lake did not lie in the direction of the greatest action of the glacier, which was straight across to the Jura where the highest erratic blocks are found. This was urged by Sir Charles Lyell, immediately after Ramsay's paper was read, and as it has quite recently been put forth by Prof. Bonney, it would appear to be thought to be a real difficulty. Yet a little consideration will show that it has not the slightest weight. No lake was eroded in the line of motion of the central and highest part of the old glacier, because that line was over an elevated and hilly plateau, which is even now from five hundred to a thousand feet above the lake, and was then even higher, since the ice-sheet certainly effected some erosion. The greatest amount of erosion was of course in the broad and nearly level valley of the pre-glacial Rhone, which followed the great curve of the existing lake, and had produced so open a valley *because the rocks in that direction were easily denuded.* Objectors invariably forget or overlook the indisputable fact that the existence of a broad, open, flat-bottomed valley in any part of a river's course proves that the rocks were there either softer or more friable, or more soluble, or by some combination of characters more easily denuded. A number of favorable conditions were combined to render ice erosion easy in such a valley. The rock was, as we have shown, more easy to erode; owing to the low level the ice was thicker and had greater weight there than elsewhere; owing to the flatness and openness of the valley the ice moved more freely there; owing to the long previous course of the glacier its under surface would be heavily loaded with rock and grit, which during its whole course would, by mere gravitation, have been slowly working its way downward to the lowest level; and, lastly, all the subglacial torrents would accumulate in this lowest valley, and, as erosion went on, would, under great hydrostatic pressure, wash away all the ground-out material, and so facilitate erosion. To ask why the lake was formed in the valley, where everything favored erosion, rather than on the plateau, where everything was against it, is to make mere verbal objections which have no relation to the conditions that actually existed.

Another objection almost equally beside the real question is to ask why the deepest part of the lake is near the south or convex side, whereas a stream of water always exerts most erosive force against the concave side.* The answer is, that ice is not water, and that it moves so slowly as to act, in many respects, in quite a

* Falsan, La Période Glaciaire, p. 153. Fabre, Origine des Lacs Alpins, p. 4.

different manner. Its greatest action is where it is deepest—in the middle of the ice stream—while water acts least where it is deepest, and more forcibly at the side than in the middle. The lake is, no doubt, deepest in the line of the old river, where the valley was lowest; and that may well have been nearer the southern than the northern side of the lake.

Another frequently urged objection is, that as the glacier has not widened the narrow valley from Martigny to Bex it could not have eroded a lake nearly a thousand feet deep. This seems to me a complete *non sequitur*. As a glacier erodes mainly by its vertical pressure and by the completeness of its grinding armature of rock, it is clear that its grinding power laterally must have been very much less than vertically, both on account of the smaller pressure because it would mold itself less closely to the ever-varying rocky protuberances, and mainly, perhaps, because at the almost vertical sides of the valley it would have a very small stony armature, the blocks continually working their way downward to the bottom. Thus, much of the ice in contact with the sides of narrow ravines might be free of stones, and would therefore exert hardly any grinding power. It is also quite certain that the ice in this narrow valley rose to an enormous height, and that the chief motion and also the chief erosion would be on the lateral slopes, while the lower strata, wedged in the gorge, would be almost stationary.

The most recent researches, according to M. Falsan, show that the thickness of the ice has been usually underestimated. A terminal moraine on the Jura at Chasseron is four thousand feet above the sea, or twenty-seven hundred and seventy feet above Geneva. In order that the upper surface of the ice should have had sufficient incline to flow onward as it did, it was probably five thousand or six thousand feet thick below Martigny and four thousand or five thousand feet over the middle of the lake. It is certain, at all events, that whatever thickness was necessary to cause onward motion, that thickness could not fail to be produced, since it is only by the onward motion to some outlet or lowland where the ice can be melted away as fast as it is renewed that indefinite enlargement of a glacier is avoided. The essential condition for the formation of a glacier at all is that more ice should be produced annually than is melted away. So long as the quantity produced is on the average more than that melted, the glaciers will increase; and as the more extended surface of ice, up to a certain point, by forming a refrigerator helps its own extension, a very small permanent annual surplus may lead to an enormous extension of the ice. Hence, if at any stage in its development the end of a glacier remains stationary, either owing to some obstacle in its path or to its having reached a level plain,

where it is unable to move onward, the annual surplus of ice produced will go to increase the thickness of the glacier and its upper slope till motion *is* produced. The ice then flows onward till it reaches a district warm enough to bring about an equilibrium between growth and dissolution. If, therefore, at any stage in the growth of a glacier a thickness of six, seven, or even eight thousand feet is needed to bring about this result, that thickness will inevitably be produced. We know that the glacier of the Rhone *did* move onward to the Jura and beyond it; that the northward branch flowed on beyond Soleure till it joined the glacier of the Rhine; and that its southern branch carried Alpine erratics to the country between Bourg and Lyons, two hundred and fifty miles from its source. We know, too, that throughout this distance it moved at the bottom as well as at the top, by the rounded and polished rocks and beds of stiff bowlder clay which are found in almost every part of its course.

In view, therefore, of the admitted facts, all the objections alleged by the best authorities are entirely wanting in real force or validity; while the enormous size and weight of the glacier and its long duration, as indicated by the great distance to which it extended beyond the site of the lake, render the excavation by it of such a basin as easy to conceive as the grinding out of a small Alpine tarn by ice not one fourth as thick, and in a situation where the grinding material in its lower strata would probably be comparatively scanty.

We have now to consider the theory of Desor, adopted by M. Favre, and set forth in the recent work of M. Falsan as being "more precise and more acceptable" than that of Ramsay. We are first made acquainted with a fact which I have not yet alluded to, and which most writers on the subject either fail to notice or attempt to explain by theories, as compared with which that of Ramsay is simple, probable, and easy of comprehension. This fact is, that around Geneva at the outlet of the lake, as well as at the outlets of the other great lakes, there is spread out an *old alluvium* which is always found *underneath the bowlder clay and other glacial deposits.* This alluvium is, moreover, admitted to be formed in every case of materials largely derived from the great Alpine range. Now here is a fact which of itself amounts to a demonstration that the lakes *did not exist* before the Ice age; because, in that case all the Alpine *débris* would be intercepted by the lake (as it is now intercepted), and the alluvium below the glacial deposits would be, in the case of Geneva, that formed by the wash from the adjacent slopes of the Jura; while in every case it would be local not Alpine alluvium.

Prof. James Geikie informs me that he considers the so-called "old alluvium" to be probably only the fluvio-glacial gravels and

sands swept out from underneath the advancing glacier, and therefore to be no older, geologically, than the moraine matter which overlies it. The Swiss geologists, however, do not appear to hold this view, since they have recourse to a very remarkable hypothesis in order to overcome what they evidently believe to be a real difficulty in the way of the pre-glacial origin of the lake. The suggested explanation is as follows: At the beginning of the Ice age the glacier of the Rhone crept on down its valley past Martigny and St. Maurice till it reached the lake; it is then supposed not to have marched on with an ice wall, say five hundred or more feet high, but to have at once spread out like so much soft pitch, and to have filled the lake to its present water level or thereabouts. Then, over this great plain of ice, the subglacial torrent of the Rhone is supposed to have flowed, carrying with it and depositing at the end of the lake that ancient alluvium which, somehow, has got to be accounted for! *

Having thus filled the lake with ice instead of water, the main body of the glacier is supposed to start afresh and to travel over the ice, and thus obviate the imaginary difficulty of a glacier moving up hill, though every student of glaciers now admits that they did so, and though it is universally admitted that this very glacier of the Rhone moved over higher, steeper, and more irregular hills on its way to the Jura and to Soleure.

Now this extraordinary theory involves two difficulties which are passed by in silence, but which seem to entirely contravene all that we know of the nature of glaciers, and to be entirely unsupported by facts. The first is, the glacier ceasing to move onward as a glacier, but spreading out to fill up a lake basin, as if the lake were simply frozen to the bottom. Is this conceivable or possible? I think not. When glaciers come down to a fiord or to the sea they do not spread out laterally, but move on till the water is deep enough to buoy them up and break off icebergs, and no reason is given why anything different should have happened in the case of the great Swiss and Italian lakes, supposing they existed before the Ice age came on. That the glacier should afterward slide over this level plain of ice is equally inconceivable, in view of the property of regelation of ice under pressure. Owing to this property the glacier and the lake ice would become one mass, and would move on together under the law of decreasing velocity with depth. This, however, is of little importance if, as I conceive, the supposition of the formation of an ice-sheet at the water level for fifty miles in advance of the glacier is an impossible one. The only other theory is, that the lake was filled up by alluvium before the Ice age, and that the glacier re-excavated it. I have,

* A. Falsan, La Période Glaciaire, pp. 135, 137.

however, already given reasons why the glacier would not have done so, and the very existence of this ancient alluvium in the course of the ancient glacier is a proof that it did not do so. This theory seems now to have no supporters.

SUMMARY OF THE EVIDENCE.—As the subject here discussed is very complex, and the argument essentially a cumulative one, it will be well briefly to summarize its main points.

In the first place, it has been shown that the valley lakes of highly glaciated districts form a distinct class, which are highly characteristic if not altogether peculiar, since in none of the mountain ranges of the tropics or of non-glaciated regions over the whole world are any similar lakes to be found.

The special conditions favorable to the erosion of lake basins and the mode of action of the ice-tool are then discussed, and it is shown that these conditions have been either overlooked or ignored by the opponents of the theory of ice erosion.

The objections of modern writers are then considered, and they are shown to be founded either on mistaken ideas as to the mode of erosion by glaciers, or on not taking into account results of glacier action which they themselves either admit or have not attempted to disprove.

The alternative theory—that earth movements of various kinds led to the production of lake basins in all mountain ranges, and that those in glaciated regions were preserved by being filled with ice—is shown to be beset with numerous difficulties, physical, geological, and geographical, which its supporters have not attempted to overcome. It is also pointed out that this theory in no way explains the occurrence of the largest and deepest lakes in the largest river valleys, or in those valleys where there was the greatest concentration of glaciers, a peculiarity of their distribution which points directly and unmistakably to ice erosion.

A crucial test of the two theories is then suggested, and it is shown that both the subaqueous contours of the lake basins and the superficial outlines of the lakes are exactly such as would be produced by ice erosion, while they could not possibly have been caused by submergence due to any form of earth movements. It is submitted that we have here a positive criterion, now adduced for the first time, which is absolutely fatal to any theory of submersion.

Lastly, the special case of the Lake of Geneva is discussed, and it is shown that the explanation put forth by the anti-glacialists is wholly unsupported by facts and is opposed to the known laws of glacier motion. The geologists who support it themselves furnish evidence against their own theory in the ancient alluvium at Geneva on which the glacial deposits rest, and which is admitted to be mainly derived from the distant Alps. But as all alluvial

matter is necessarily intercepted by large and deep lakes, the presence of this Alpine alluvium immediately beneath the glacial *débris* at the foot of the lake indicates that the lake did not exist in pre-glacial times, but that the river Rhone flowed from the Alps to Geneva, carrying with it the old alluvium, consisting of mud, sand, and gravel, which it had brought down from the mountains. Still more conclusive, however, is the fact that the three special features which have been shown to indicate erosion rather than submergence are present in this lake as fully as in all other Alpine valley lakes and unmistakably point to the glacial origin of all of them.

On the whole, I venture to claim that the facts and considerations set forth in this paper show such a number of distinct lines of evidence, all converging to establish the theory of the ice erosion of the valley lakes of highly glaciated regions—a theory first advocated by the late Sir Andrew Ramsay—that that theory must be held to be established, at all events provisionally, as the only one by which the whole body of the facts can be explained and harmonized.—*Fortnightly Review.*

[*Concluded.*]

SKETCH OF GERARD TROOST.

GERARD TROOST, one of the founders and first President of the Academy of Natural Sciences of Philadelphia, was born at Bois-le-Duc, Holland, March 5, 1776, and died in Nashville, Tenn., August 14, 1850. He attended the Universities of Leyden and Amsterdam, devoting special attention to chemistry, geology, and natural history; received the degree of Doctor of Medicine from the University of Leyden, and that of Master in Pharmacy, in 1801, from the University of Amsterdam. He practiced his art for a short time at Amsterdam and the Hague; served in the army as a private soldier, and at another time as an officer of the first class in the medical department; and during these periods of service was wounded in the thigh and in the head. In 1807 he went to Paris, under the patronage of Louis Napoleon, King of Holland, to pursue his studies, and then he became the pupil and associate of the Abbé René Just Haüy, author of the famous system of crystallography. He traveled in France, Italy, Germany, and Switzerland, and collected a valuable cabinet of minerals, which was purchased by the King of Holland. In 1809, this king appointed Troost to accompany, in a scientific capacity, a naval expedition to Java. He was captured by an English privateer; confined for some time at Dunkirk; returned to Paris; and

then made his way to la Rochelle. He took passage from a northern port, beyond French jurisdiction, in an American vessel, for New York, whence he hoped to reach the East Indies under the protection of our flag. This vessel was captured by a French privateer and carried to Dunkirk, where Troost was kept a prisoner till the French became aware of his true name and character, when he was released. He went at once to Paris. In March, 1810, he was elected a correspondent of the Museum of Natural History of Paris. A few days afterward he was allowed to embark again on an American vessel for Philadelphia. The turn of political events in Europe, among which was the abdication of Louis Napoleon as King of Holland and the surrender of Java to England, caused him to abandon his contemplated visit to the East Indies and to remain in the United States.

In 1812 Dr. Troost participated in the foundation of the Academy of Natural Sciences in Philadelphia and became its first president. Of the origin of this society, Dr. W. S. W. Ruschenberger, from whose account we derive much of the material of this sketch, says there were some young persons in Philadelphia disposed to study the laws of creation. Occupied with their business during the day, they were accustomed to converse concerning natural phenomena when they met in the evening, without appointment, at the ordinary places of resort. They very often met at the apothecary's shop of John Speakman, of whom Thomas Say was subsequently the business partner, at the corner of Market and Second Streets. At one of these meetings Mr. Speakman suggested that if the young men could be induced to meet at stated times, where they would be secure from interruption, to communicate to one another what they might learn about the phenomena of Nature, they would derive more pleasure and profit than from desultory and irregular conversation. The suggestion was seconded by Jacob Gilliams, and a meeting was appointed for the next Saturday evening at Mr. Speakman's house, for the young men and such of their friends as might be interested in the matter: Six persons were present at the meeting, January 25, 1812; Dr. Gerard Troost, Dr. Camillus Macmahon Mann, Jacob Gilliams, John Shinn, Jr., Nicholas Parmentier, and John Speakman, host. The meeting was described in the minutes as "a meeting of gentlemen, friends of science, and of rational disposal of leisure moments"; and it was agreed that the exclusive object of the society should be the cultivation of natural science. For the furtherance of this purpose all matters of politics and religion were rigorously excluded, even allusions to them being forbidden. It was perhaps from this determination, Dr. Ruschenberger suggests, that "the erroneous notion

sprang, which, according to tradition, prevailed with some, that the object of the institution was to favor religious infidelity." The constitution of the society was agreed upon on the 17th of March, and the name Academy of Natural Sciences was adopted on the 21st of that month, which date was established as that of the beginning of the institution. On that day, too, the members agreed "to contribute to the formation of a museum of natural history, a library of works of science, a chemical experimental laboratory, an experimental philosophical apparatus, and every other desirable appendage or convenience for the illustration and advancement of natural knowledge, and for the common benefit of all the individuals who may be admitted members of our institution." Among the first donors of minerals were Dr. Troost, Mr. Isaac Lea, Dr. Hays, and Mr. S. Hazard. When the small room, 121 North Second Street, hired about the 1st of April, was occupied, the members came forward with their gifts to serve as the nucleus of the museum and library. Among them was Dr. Troost, with some artificial crystals, prepared by himself. On the occasion of the election of officers, May 7, 1812, Dr. Troost was chosen president. He held this office five years, or till 1817, when he resigned and was succeeded by William Maclure. On the 15th of August, 1812, the collection of minerals previously purchased from Dr. Seybert by Mr. Speakman came formally into the possession of the society, which formed a kind of joint-stock company to pay for it and hold it. Soon after this, Dr. Troost delivered a course of lectures on mineralogy before the academy.

During his residence in Philadelphia Dr. Troost was engaged in manufactures of various kinds. In 1815 or 1816 he began the manufacture of alum on the Magothy River, Cape Sable, Maryland, establishing the first alum works in the United States. In 1821 he was appointed Professor of Mineralogy in the Philadelphia Museum, where he delivered lectures on the subject. He was also appointed about the same time first Professor of Chemistry in the College of Pharmacy, Philadelphia, a position which he resigned, after having delivered one course of lectures, in the succeeding year. During this period he also made geological excursions into New Jersey, New York, and elsewhere.

In 1825 Dr. Troost, with Maclure, Say, and Lesueur, joined Robert Owen in the formation of the Communistic Society at New Harmony, Ind. After remaining there two years, he removed to Nashville, Tenn., in 1827. In 1828 he was elected, at the instance of President Lindley, Professor of Chemistry, Geology, and Mineralogy in the University of Nashville. In a historical sketch, published in the catalogue of 1850, is a table of the longest terms of official service of instructors. It is headed by President Lind-

ley, twenty-six years; and next in length of service comes Prof. Troost, from February 9, 1828, to August 14, 1850, twenty-two years and a half.

In 1831 he was appointed State Geologist of Tennessee, an office which he held till it was abolished in 1839. The record of his work in this department is preserved in his reports. The first and second reports were not published. The third report, made in 1835, contains the results of the geologist's investigations respecting the extent of the coal formations in the State. "I have ascertained," it says, "that the places in which coal may be expected belong exclusively and entirely to that group of mountains which are known by the name of Cumberland Mountains, and are composed of Walden's Ridge, Crab Orchard Mountain, Brimstone Mountain, and some other subordinate ridges of the same system." The breadth of the formation was greatest near the northern limit of the State, and in one part the coal was represented as deposited in horizontal strata of great extent. The report also deals largely with marl, iron, and soils, and concludes with the words: "In a scientific point of view my labors have been very advantageous. I have been very fortunate in obtaining organic remains which were unknown, and which eventually will show how far our strata correspond with those on the old continent. I have discovered parts of the American or *gigantic mastodon* hitherto unknown."

The fourth report, of 1837, relates to the Ocoee district, comprising a part of the mountain region near the North Carolina boundary, which Prof. Troost was directed by the State Legislature to explore. It begins with an exposition of the principles of geology and their application to the general structure of the district under view, for the information of the people; an admirable specimen of exact scientific writing adapted to popular comprehension, explicit, lucid in style, and showing familiarity with the subject. The character of the region is depicted in a few words: "Commencing our reconnaissance at the most northern extremity of the district, I found the rocks at Tallassee, on the Tennessee River, entirely composed of grauwacke, alternating here and there with limestone; this is the case everywhere along the Tennessee River, where I was able to approach and examine them, to the Smoky Mountain, which forms the southeastern limit of the district, and separates Tennessee from North Carolina. It is almost impossible to penetrate any distance in this wild and mountainous country; and the apparent confusion of the rocks, which seem at some places heaped up without order, and changing at small distances, makes the geological survey hazardous and extremely difficult." The author calls attention to the roofing slates of East Tennessee, and dwells upon the value of slates

generally; regards the prospects of finding paying gold as not promising; but speaks of having observed at several places between the Ocoee and Hiawassee Rivers hydroxide of iron similar to the ore used in Middle Tennessee in the blast furnaces. "It is superfluous," he adds, "to expatiate here on the importance of iron works in a country which is not susceptible of cultivation, where there is an inexhaustible supply of wood." He suggests in this report a hypothesis that Lookout and Raccoon Mountains and the Cumberland Mountains were once connected, and that the Tennessee River cut a passage between them; and he gives reasons for believing that the old bed of the river may be found where it enters the Sequatchy Valley. A note is added to the report, giving a list of the fossils the geologist had collected during his survey. He believed that his collection, particularly of fossils characterizing the mountain limestone of Tennessee, was unrivaled. It was his desire to have them figured and described, and published as an appendix to the work of Dr. Goldfuss on organic remains, of which he had announced a translation—but "the prospect of publishing it without pecuniary loss is not flattering." The list contains nearly a hundred entries, some of which include many species.

In his fifth report, made for 1839, Dr. Troost said that he had traversed the State in many directions, and analyzed a large number of minerals, mineral soils, and other materials, which, though not belonging properly to the department of the geologist, were deemed necessary to be known as constituting sources of our national wealth. The report gives a general view of the geology of the whole State, in which all the terms are clearly and fully explained. It deals with iron ores, timber, and water powers, and points out the suitableness of the region of the Smoky Mountains for grass and stock and the cultivation of potatoes and cabbage—adding that "no country can be better calculated for the raising of sheep." Prof. Troost insisted that iron must become one of the principal sources of wealth of Middle and East Tennessee, which were even more favored in the distribution of ores than Missouri with its Iron Mountain, and "nowhere could a foundry for a national arsenal be more judiciously situated than in our State, the center of the Union, and therefore not liable to be attacked by an enemy, and yet by means of its large rivers, and soon perhaps of railroads, cannon or other arms may be transported in a short time to any point in the Union." Descriptions of iron ore and iron works are given with some detail. The list of organic remains is accompanied with descriptions and includes a hundred and sixteen entries.

The ninth report, for 1847, deals chiefly with zinc ores, their reduction, and the manufacture of zinc and brass.

Of the report made in 1849 the American Journal of Science and Arts said: "The geographical survey of Tennessee, under Dr. Troost, is still in progress, and is bringing to light many additions to science, besides developing the various resources of the State. Prof. Troost is well known for his learning, his skill, and his enthusiasm in his investigation, and it is greatly to the honor of Tennessee that such a *savant* is appreciated and his talents are called into action. In a recent communication from Dr. Troost he mentions that the number of the new genera and species of *Crinoideæ* which occur in the State of Tennessee is really surprising. His geological report, now before the Legislature of the State of Tennessee, contains a monograph of *Crinoideæ* in that State, in which sixteen new genera and eighty-eight new species are described, illustrated by two hundred and twenty figures; this number not only surpasses that of those discovered in the other States of the Union, but perhaps is equal to those that have been found over the whole of Europe."

Besides his geological reports of Tennessee, Dr. Troost contributed to the Philadelphia Society for Promoting Agriculture, A Geological Survey of the Environs of Philadelphia, the territory included in which embraced a semicircular area having a radius of fifteen miles from the center at the Rotunda in High Street, and bounded on the east by the Delaware River. A preliminary note described the paper as "an attempt to delineate the geological positions of our environs, and to give some general ideas of the nature and chemical constituents of our soil." Of the pamphlet of forty pages, containing a colored map, ten pages were devoted to the geological survey, fifteen pages to descriptions of soils, and ten pages to their composition. Prof. Troost also published in the Transactions of the Geological Society of Pennsylvania an account of the organic remains and various fossils of Tennessee and adjacent States; in the Bulletin of the Geological Society of France, a memoir on the organic remains and fossils of Tennessee; and in Silliman's American Journal of Science and the Arts, articles on Amber at Cape Sable, Maryland; Minerals of Missouri; Coral Regions of Tennessee; Analysis of a Meteorite from Tennessee; Meteoric Iron from Tennessee and Alabama; A Shower of Red Matter in Tennessee; Three Varieties of Meteoric Iron; Meteoric Iron of Murfreesboro', Tenn.; and Krausite and Cacorene in Tennessee. He translated Humboldt's Aspects of Nature into Dutch. He gathered a collection of about fifteen thousand mineralogical and more than five thousand geological specimens, constituting what was at the time considered the finest cabinet belonging to a single person in the United States. Besides the Philadelphia Academy, he was a member of the

American Philosophical Society, the Geological Society of Pennsylvania, the Geological Society of France, and of other scientific bodies in America and Europe.

A minute adopted by the Board of Trustees of the University of Nashville, on the occasion of the death of Prof. Troost, relates that, "born and liberally educated in Holland, he early manifested a zealous devotion to natural history and chemistry, more especially to the then infant sciences of geology and mineralogy. With a view to the more successful pursuit of his favorite studies he visited Paris, and was for several years the pupil of the celebrated Haüy. He removed to the United States about forty years ago, and in due time became an American citizen. His entire life was consecrated to geology and the kindred sciences, with what ability and success his published writings and his well-earned reputation at home and abroad may eloquently testify. As a professor in this university during the last twenty-two years and a State geologist of Tennessee for the most part of that period, he won the confidence and respect of the community by invaluable service in both capacities, as well as by the unaffected modesty, kindness, and uniform courtesy of his deportment toward all men. In the various relations and stations of life, public and private, he was without reproach and above suspicion. Beloved, trusted, honored, venerated by all those most intimately connected or associated with him, he could not make an enemy—he had none."

Geography as a whole was compared by Dr. H. R. Mill, in the introduction to his course of educational lectures of the Royal Geographical Society, to a pyramid of six courses of masonry, built of blocks obtained from different quarries. The first and fundamental course, built of material derived from pure mathematics, was mathematical geography, absolutely secure and firmly established, underlying all the rest. Upon it, and resting on it, rose physical geography, the material for which was brought from physics, geology, meteorology, etc., all the determining conditions being fully known. This served as a foundation for biological geography, in which the imperfect comprehension of life introduced unstable and incomplete elements; but far fuller of uncertainty was the next tier of anthropo-geography, in which the additional unknown quantity of human nature exercised a preponderating influence, and the positive scientific facts from the quarries of anthropology, ethnology, and economics were few and by no means well co-ordinated. Arising from this came the layer of political geography, the scientific basis of which was mixed up and overlaid with arbitrary, transitory, and impracticable conditions arising from the workings of the human mind and the limitations of nationality. Upon this was reared the final story of the pyramid, commercial geography, a mass of rubble, the relation of which to its scientific foundation was not yet fully made out.

CORRESPONDENCE.

MISTAKES OF SCIENTIFIC MEN, ARTISTS, AND POETS.

Editor Popular Science Monthly:

In late numbers of this journal public attention has been called to errors in the statement of facts or of scientific points, by men who should have known better. But errors of the kind you name are not confined to a few, but are found everywhere—even among poets and artists, as well as among men of science.

Some years ago a French artist was employed to paint a panel on the west wall of the room belonging to a lodge. He made a beautiful evening landscape, having the sun in the horizon. A little above, and toward one side, was the *full moon*. The shadows of the trees in the foreground all pointed to the *moon* as their source, although the whole circle of the sun was still in view. I called his attention to this want of conformity to the facts—but the picture was too good to be spoiled by corrections; so it remained as it was made.

There is a beautiful hymn by Seagrave, found in many church collections, having a part of a stanza as follows:

> "Rivers to the ocean run,
> Nor stay in all their course;
> Fire, ascending, seeks the sun,
> *Both speed them to their source.*"

[All the Italics in this letter are my own.] The science contained in these lines is that of the ancient heathen philosophy, viz., that things heavy naturally *tend downward*, things light naturally *tend upward.*

The attribute of intelligence thus given to the fire has but a sorry exemplification, seeing that all fires which burn in the night fail to get a right start in their search for the sun. Of course, it is meant that the fire goes upward of its own accord—is not driven by anything else.

A distinguished professor of physics in an Ohio college many years ago was accustomed to say in his lectures that "hot air rises, and the cold air rushes in to fill the vacuum." I once called his attention to the slip. He acknowledged the error—and then continued to speak as before, much after the manner of the devil when he was sick and wished to be a monk.

The same absurd statement appears in The Popular Science Monthly for last November, page 104, in the article on the origin of The Mississippi Valley Rainfall. We find as follows: "They [the winds] flow as on an inclined plane, over the colder and more dense air toward the north, and thus restore the equilibrium of the atmosphere that has been disturbed. This disturbance is caused by a continual flow of the cold and heavy surface air from the extreme north toward the equator, because along the tropical belt *a partial vacuum is created* by the air becoming heated and lighter, and in consequence *floating upward, and the cold air rushes in to supply that vacuum.*" There it is.

Again, in the February number of this year, page 466, in the article on the Physical Conditions of the Deep Sea, occurs this passage: "The particles of water thus heated *immediately commence to rise through the superjacent layers of colder water, and the colder particles would fall to take their places.*"

On the principles of the ancient philosophy these extracts are all right, but according to the principles of modern physics they are all wrong. Your own rebuke to such carelessness was well deserved—let us hope that it may produce needed reformation.

R. W. McFarland.

Columbus, Ohio, *April* 1, 1894.

DO ANIMALS REASON?

Editor Popular Science Monthly:

The February number of The Popular Science Monthly has just arrived, and I should like to add to the article on the Psychology of a Dog two illustrations.

When my father was in the navy during the late war, his ship, the United States bark Pursuit, lay at St. Joseph's Bay, Florida. There was on board a dog (half pointer) called "Secesh" because he had been captured from the "rebs." One day the men went on shore, taking "Secesh" with them, but when the time came to return the dog was nowhere to be seen, and the men were obliged to go back without him. Half an hour later Secesh appeared upon the beach and, finding the boat had gone, he started to swim for the vessel; but before he reached it the tide caught him and was carrying him rapidly out to sea; he thereupon swam back to the shore, trotted rapidly up the beach for a considerable distance, and again struck out for the ship, this time reaching it in safety.

Again: my grandmother was possessed of a small dog of no particular breed. One evening she, with my grandfather, was talking of going to visit her mother, some twenty miles distant, on the following day. Dick, the dog, lay on the hearth at their feet. My grandmother remarked that they had better shut Dick up before they started or he would follow them. In the morning Dick was nowhere to be found, and they were obliged to

start without fastening him. They had proceeded a number of miles on their journey when they came to a place where two roads diverged. There at the fork of the roads sat Dick, serenely waiting to find which road to take. You may be sure he was not sent back.

Is it not certain that these dogs must have reasoned, and if they reasoned, is it not logical to conclude that dogs have a mind; then, if they have a mind, is this mind not immortal? Any child may ask these questions, but what child or philosopher will give them a satisfactory answer?

HELEN BLACKMER POOLE.

SPRINGFIELD, MASS., *January* 19, 1894.

EDITOR'S TABLE.

THE POSSIBILITIES OF EDUCATION.

THE article from the pen of Prof. C. Hanford Henderson, which appeared in our last number under the title of Cause and Effect in Education, is one deserving of more than passing attention. The point he sought to make was that education as an art can hardly be said as yet to have entered on its scientific stage, seeing that it is still haunted by so many unverified *a priori* conceptions, and that the true limits and conditions of successful working are still far from being generally understood. The general subject is one which has been very often discussed in these columns, but it is also one on which there always seems to be another word to say.

Education, from one point of view, is a debt which the adult generation owes to that which is to succeed it. This civilization to which we have attained, these general ideas, these intellectual resources, these moral principles, these habits and customs of proved utility—how are they to be passed on to those who are to succeed us? By education—that is to say, by mental contact and moral sympathy between those who know and those who as yet do not know. That is the problem in its most general aspect. Here we may make two reasonable assumptions: the first, that all we have learned the rising generation may also learn; the second, that possibly, nay probably, it is not worth the while of the rising generation to learn *all* that we have learned. We can not teach our children more than we know, but we can teach them less than we know, and so leave room for their own independent acquisitions. It behooves us, therefore, to sift our knowledge and whatever else we have to impart, and consider very carefully what is worth passing on and what is not. Much good, we believe, would come from a serious and earnest facing of this question, What should I teach or have taught to my child in its own best interest? Things which we ourselves have learned, perhaps with considerable effort or at considerable cost in other ways, we are apt to attach a fictitious value to, simply because they have cost us dear; but the spirit of virtuosity should not enter into education; let the child become a *virtuoso* after his own fashion later if circumstances lead him to do so, but meantime let our chief effort be to give him a free and healthy mind in a free and healthy body.

One thing is certain: every child, every human being, wants the full use of his senses and other natural faculties. Eyes were made to see with, ears to hear with, vocal organs to speak and sing with, and hands to feel with. Any system of education, therefore, that is inspired by true benevolence toward the child will start by taking stock of his natural endowments, so as to correct, as far as possible, any defects that may attach to them and provide for their fullest development. Children are often far from perceiving the benevolent intent in the systems of education

to which they are subjected; and it is little wonder, in general, that it should be so. But, if an effort were being vigorously made to carry every natural faculty they possessed to its perfection—to make the eyes quick and true, the voice sweet and full, the hearing sensitive and discriminating, the bodily movements vigorous and graceful, and so on—the beneficence of the process would impress itself even on the juvenile mind, and thus half the battle would be gained, for we want the children's confidence before we can do them much good. Nothing, we believe, would do so much toward the development of the all-important quality of self-respect as a careful physical training. It would, on the one hand, promote individuality, inasmuch as the child would be made to feel what he or she was capable of individually, and, on the other, it would promote a true comradeship, as it would awaken a consciousness of that common physical nature, with its varied powers, of which all partake.

Here, therefore, is a part of education about which there can be no mistake—a preparation for perfect living in the physical sense—that perfect living which economizes both mental and moral force, and places the individual in a position of advantage for the accomplishment of all the ends of life. Under a system which made due provision for this kind of training, questions of diet, of clothing, of exercise, of ventilation, of bodily habits, and so forth, would, of course, be carefully considered, and whatever was best in all these respects would be suitably held up for guidance and instruction. It is true that there is much that is defective from a hygienic point of view in the home life of nearly all classes, and on that very account it is important that true hygienic principles should be inculcated, in a manner as free as possible from pedantry, in the schools; for if the children can be taught simply and clearly the conditions on which their health and comfort depend, they will themselves exert a wholesome influence in the household.

What Paul said to the Athenians might be said to-day to ourselves: We are in all things too superstitious, and particularly in the matter of education. Instead of seeking as we do now to see how much we can cram into youthful minds, or in other words how much of the elastic force of the brain we can destroy—for that is what it comes to in at least a multitude of cases—we should consider all so-called knowledge contraband of the childish mind until its assimilable character has been fully demonstrated. When we are satisfied that it will act as food and not as the mere stuffing of the taxidermist to bulge out the intellectual nature into a conventional shape, let us impart it, and not before; but do not let us give too much even of food, remembering that the animal which goes in search of its own food gets the highest and best development, the most ingeniously adapted structure, the widest range of faculty. The most fatal fault we can commit is that of unduly taming and domesticating the mind, so to speak, so that it expects to be fed by others, instead of going abroad to see what the universe will do for it.

The more we expect from education, the less we are apt to get from it in the way of useful results. We form an idea of a highly rationalized man of refined intellectual and artistic tastes, with perhaps a large element of moral idealism, and generally "up to date"; and that we set up, as Nebuchadnezzar did his brazen image, for all the world to bow down to. The object of education, we think, is to produce something like that. Well, education isn't going to do it. Men of that kind have always been exceptional, nor is it education that has given them the qualities we so much admire. If education had done it for them, why then, doubtless, it could do it for others; but what do we see? From the same

form in school, perhaps from the same household, one will rise to honor and another sink to dishonor; one will become conspicuous in society, another will never emerge from obscurity. But what education *will* do, if we work on natural lines, if we are not too fussy over it, and are careful not to give it in too large doses, will be to liberate and more or less wisely direct a vast amount of intellectual power which at present we confine and almost paralyze. Good and sensible people are often heard groaning over the vulgar and frivolous enjoyments which alone seem to afford any pleasure to the multitude; and there is some reason for the plaint, though the multitude may not be so much to blame as is supposed. It is a question of intellectual energy. The man or woman who has much of it to spare will not be a frequenter of the mere spectacular drama, nor a devourer of coarsely sensational novels. What excuse is sometimes given by our busy men for their very inferior taste in literary, dramatic, and other matters? Oh, that they are so fagged out by their day's work that they want the stimulus of something sensational. The excuse is worked for all that it is worth; but in some cases there is something in it. As regards a much larger number, however, both of men and of women, the trouble probably is that their intellectual faculties were not only not strengthened or invigorated by their early education, but were more or less dwarfed and numbed. If a youth were to go through an alleged course of athletic training and were to come away with dwindled muscles and a more languid condition of body than he had when he began, we could at once, on the evidence of our senses, pronounce the whole thing a fraud. The mind, unfortunately, does not admit of the same simple measurements as the muscles, and we can not therefore so easily detect the fraud when, after from five to ten years of schooling, a young person steps out into the world with less of intellectual apprehensiveness and less of available mental vigor than he or she had as a little child. Yet, that this has been, and still is, a not infrequent result, who will deny?

There are great possibilities of good in education if we will but recognize our proper *rôle* in the matter, and not try to usurp the place of the one consummate teacher—Nature. There are vast possibilities of evil in it if, planting ourselves on dogmas, traditions, and classicisms, or attaching too absolute an authority to our own generalizations, we seek to dominate the minds whose gradual evolution we should patiently watch and cautiously and tenderly assist. Most of us probably have more or less teaching to do: let us remember that, so far as this is the case, our art is not that of the taxidermist or constructor of lay figures, but that we have living tissue to deal with; and let us respect the mysteries of life and growth.

IS "SOCIETY" VULGAR?

Some weeks ago a prominent clergyman of this city was reported to have expressed the opinion that the "society" of to-day is vulgar. Reporters called upon him to ascertain if he really had said anything so dreadful, and he was obliged to confess that he had, and that he really thought he had spoken the truth. It is evident that whether he did speak the truth or not depends on the sense we attach to the word vulgar. If to be vulgar means to live plainly and without ostentation, then society is not vulgar, but very much the opposite. If to be vulgar means to take unconventional views of things, and to estimate men and women more according to their intellectual and moral qualities than by the wealth they possess and the figure they are able to cut in the world of fashion, then to say that society is vulgar is a cruel slander. If to be vulgar is to be unversed in social forms, but sincere in friendship,

then society deserves no such reproach. Finally, if to be vulgar means to possess and cultivate individuality, to study the principles of taste, and to consider these as more entitled to respect than the dictates of fashion, to regard advantages of wealth and position as held in trust for mankind at large, and to make the enjoyment of pleasure secondary to the performance of duty, the accusation of vulgarity is very much beside the mark.

The word "vulgar," as we all know, means "appertaining to, or characteristic of, the multitude." We have not turned up the word in the dictionary, for we feel sure this definition will suffice. An infallible rule, therefore, for being vulgar according to the measure of your ability, is to keep your eye on others, so that whatsoever they do you may do also, irrespective of your own judgment as to the merits of the particular act or course of action. If you begin to study the right or wrong of the thing, to consider whether what suits, or seems to suit, others is also suitable to you—if, in a word, you bring private judgment and a moral or æsthetic conscience to bear on the matter—you at once run the risk of not being vulgar, and that is a risk which a good many persons do not care to run. "As well out of the world as out of the fashion" is the whole law and gospel of vulgarity, seeing that it is the maxim which compels people to abnegate and set at nought their private judgment, and act blindly in troops at the bidding of some unseen and possibly very despicable master of ceremonies.

We begin to see now, perhaps, what the eminent clergyman meant when he said that "society" was vulgar. He did not mean any of the things first hinted at. He was thinking of the essential meaning of the word. He saw, with a clearness of vision which it would be well if all ministers of the gospel possessed, that luxury does not shut out vulgarity, that so-called polite manners are not incompatible with it, that even educational acquirements may only, like varnish, bring out its grain more distinctly. He saw that "society," when all is said and done, lives mainly to eat and drink and nourish the bodily senses; that far from believing in and cultivating individuality, it represses it to the utmost; that, instead of discussing, like citizens of a free republic, the codes by which it is governed, it only asks to know that they have been imposed by some recognized authority; that, in a word, it is whatever is most commonplace, glorified by the power of gold. So he ventured to say it was vulgar, and, if it is not, then what is it? It is, broadly speaking, a region of tinsel, of monotonous routine, of rival vanities so alike in their expression that one is hardly to be distinguished from another, and of slavish imitation. The way of escape from this City of Destruction lies through the cultivation of individuality and thoughtfulness for others. As the essence of vulgarity is to be a selfish, unreflecting slave of fashion, so the farthest remove from it is to be a freely thinking, judging, and acting individual, seeking ever higher modes of life, and desiring to communicate as much of good as possible to others. The aim of education ought to be to rescue from vulgarity and win over to a broad humanity—to plant the law of reason in the mind and the law of love in the heart.

The several psychological works of Prof. James Sully are so widely read and frequently cited in America that their author needs no introduction to the readers of the Monthly. Accordingly, we feel that we are making a very welcome announcement in stating that Prof. Sully has consented to contribute to this magazine a series of articles embodying some of the studies of mental development in childhood that he has been making during the past few years. The first of these articles, under the

special title, The Age of Imagination, will appear in our July number. It deals with what the author calls "the *play* of imagination, the magic transmuting of things through the sheer liveliness and wanton activity of a child's fancy." The mind of the child is still a little-explored country, and an examination of it under Prof. Sully's competent guidance will not only have the charm of novelty but will also furnish much helpful insight to all who have the care of children.

LITERARY NOTICES.

Edward Livingston Youmans, Interpreter of Science for the People: A Sketch of his Life, with Selections from his Published Writings and Extracts from his Correspondence with Spencer, Huxley, Tyndall, and Others. By John Fiske. New York: D. Appleton & Co., 1894. Pp. 600. Price, $2.

Few men of this generation in America have better deserved an enduring monument to their memory than the late Prof. Edward L. Youmans. Such a monument, we may trust, is supplied by the ably written biography by Prof. Fiske. The author was intimately acquainted with him for many years, and has produced a most interesting and pleasing sketch of his character and career, one marked, as might have been expected, by ardent and enthusiastic sympathy with his subject, yet equally characterized by moderation and good taste. Let us first glean a few of the biographical details furnished by Mr. Fiske.

Edward Livingston Youmans was born in the town of Coeymans, Albany County, N. Y., on the 3d of June, 1821. His father, Vincent Youmans, is described as "a man of independent character, strong convictions, and perfect moral courage," and his mother, Catherine Scofield, as "notable for balance of judgment, prudence, and tact." Both father and mother belonged to the old Puritan stock of New England, and in Edward Youmans the best and richest qualities of that stock came to the surface—"sagacity and penetration, broad common sense, earnest purpose, veiled but not hidden by a blithe humor, devotion to ends of practical value, and the habit of making in the best sense the most out of life."

A few months after Edward Youmans was born, his father, who pursued the occupation of wagon-maker, removed from Coeymans to Greenfield, in Saratoga County. Here and in the neighboring town of Milton, to which he removed ten years later, five other sons and one daughter were born, and Edward, as the eldest child, took an active and very willing part in looking after the younger ones. Until his sixteenth year he helped his father at work in summer and attended the district school in winter. The most wholesome feature of such schools was an absence of overregulation. It was one that Edward learned early to appreciate, and he always cherished a distrust of excessive organization and a dislike to machine methods.

At the age of thirteen the youth became possessed of a copy of Comstock's Natural Philosophy, and shortly set to work to repeat some of the experiments therein described. He next obtained a copy of Comstock's Manual of Chemistry, which he studied as best he could by himself, for his school-teacher had no knowledge whatever of the subject. From it he gathered the opinion, as Prof. Fiske tells us, that, "when men have once learned how to conduct agriculture upon sound scientific principles, farming will become one of the most wholesome and attractive forms of human industry."

Such was the youth of Edward Youmans, such the stock from which he sprang, such his original habitat and environment. Our narrative up to this point presents no remarkable features, and yet this home-bred youth was destined to do a great work—to be, if we may use the expression, the foster-father of a great system of philosophy on the North American continent, the virtual leader of the intellectual forces that rallied under the banner of evolution. As a man he had these two great qualifications for practical success: he knew a good thing when he saw it, and what his hand found to do he did with his might. But before he entered upon his work as a teacher and champion of evolution and general popularizer of science, he was destined to pass through a very painful period of his life—a period during which he

suffered from disease of the eyes, involving weary months and years of sometimes partial, sometimes total, blindness.

Altogether he struggled for fifteen years with this terrible disability, dating from the time when his eyes were first attacked in his fifteenth year. These years, however, were not years of idleness: when he could not see he could listen, and his sister, who was seldom far from his side, would read to him from any book he might indicate. Between being read to and reading for himself, when it could be done with any safety, he vastly increased his stores of knowledge, and particularly became so proficient in chemistry that he was able to produce a text-book which had immediate success, and which, in a revised form, is holding its ground to this day.

No sooner had he recovered a fair measure of sight than he betook himself to the delivery of popular lectures on scientific subjects; and here he seemed to have found his true vocation. The people heard him gladly, and more engagements were offered than he was able to accept. The work, however, was not without its dangers: the lecture season was of course in the winter, and in his journeyings to and fro Mr. Youmans was frequently exposed to chills, and was laid up more than once with severe bronchial and pulmonary attacks. If dangerous to the lecturer, the work was useful to the multitude. "Many a young man," observes his biographer, "in many a town could trace to Youmans and his lectures the first impulse that led him to seek a university education. In quarters innumerable his advice gave direction to family reading in the best treatises on astronomy, physics, chemistry, geology, and physiology."

It was not in the lecture field, however, that he was destined to do his most important work. In the year 1856 he saw in a periodical an article on Spencer's then recently published Principles of Psychology. He sent for the book, and saw, to use Prof. Fiske's words, that "the theory expounded in it was a long stride in the direction of a general theory of evolution." He then read Spencer's Social Statics, which had appeared a few years earlier, and, as we are told, "began to recognize Spencer's hand in the anonymous articles in the quarterlies in which he was then announcing and illustrating various portions or segments of his newly discovered law." Finally, in the year 1860, he was shown a copy of the circular in which Spencer was announcing his philosophical series. That such a man should be appealing for support, to enable him to bring out works of so transcendent importance, suggested at once to Mr. Youmans that here was a chance for him to render service which might be of much moment. He took what he felt at the time to be the bold step of writing to Spencer, and offering to interest himself in getting American subscribers to the series. Mr. Spencer replied, thanking him very warmly for the offer and for the sympathy which his letter had expressed; and thus was begun a friendship of the most sincere and enduring character between these two eminent men. Nothing in the volume before us is more interesting or produces a pleasanter impression that the extracts given from the correspondence which passed between them from this date onward to the death of Mr. Youmans.

The result of the acquaintance thus formed was that Spencer obtained a gratifying number of subscribers to his series in this country, and that the republication of his works was begun by Messrs. D. Appleton & Co., who were the publishers of Youmans's Chemistry and of another work which he had produced under the title of Handbook of Household Science. This was really the turning point in Spencer's fortunes. In one of his letters to Youmans we find the following passage: "The energy and self-sacrifice you continue to show in the advancement of my scheme quite astonishes me; and while, in one respect, it is very gratifying to me, yet in another it gives me a certain uncomfortable sense of obligation, more weighty than I like to be under." This shows the relations that had been established between the two men, and makes the action which Youmans so vigorously, we might say heroically, took at a later date to help his friend through a financial crisis entirely natural. Such he was to Spencer all through—the one untiring upholder of his name, defender of his views, and good providence of his fortunes on this continent. Spencer and the evolution philosophy were inseparable in his thoughts, and for so great a cause repre-

sented by so great a name no sacrifice was too great.

We are nearly at the end of our space, without, unfortunately, being nearly at the end of our subject. The travels of Mr. Youmans in England and on the continent of Europe, sometimes in the company of Spencer; his correspondence with members of his family in this country; his labors in arranging for the publication of the International Scientific Series, in connection with which he visited Paris, Berlin, and Leipsic, and came into personal relations with the leading *savants* of France and Germany; finally, his establishment of The Popular Science Monthly, chiefly on the strength of a series of original articles by Spencer, on The Study of Sociology, would admit of extensive and interesting treatment; but for all this we must refer our readers to the book itself. The aim of this notice has been to indicate to the many who knew Prof. Youmans only by name what manner of man he was, and what services he rendered in the cause of intellectual progress. Prof. Fiske, with the skill of an accomplished writer and the sympathy of an intimate friend and most sincere admirer, has given the finer as well as the broader lineaments of his character in a manner that leaves little to be desired. That so energetic a worker, with so capable a brain and so large a heart, should have died at the comparatively early age of sixty-five is a matter for profound regret, particularly as we are compelled to attribute it to the same want of care for his general health and over-devotion to work which brought on, and then aggravated, his early trouble with his eyes. As a writer Prof. Youmans had a style of his own, full of nervous force and grace—a style ample and rich, and yet admirably precise. Some of his essays are published as an appendix to the biography, and form most interesting and instructive reading. From these his dominant ideas and purposes may be gathered; and no one can read many pages without seeing and feeling that here was no intellectual dilettante, but a man with a mission, and that the lofty one of dissipating ignorance and prejudice, spreading the light of science, and preparing the way for those "nobler modes of life" of which seers have prophesied and poets sung.

The Genus Salpa. A Monograph, with Fifty-seven Plates. By William K. Brooks, Ph. D., LL. D. With a supplementary Paper by Maynard M. Metcalf. Memoirs from the Biological Laboratory of the Johns Hopkins University. Vol. II. Baltimore, 1893. Price, $7.50.

This bulky quarto, with its companion volume of fifty-seven plates, is a monumental work. It is the result of years of concentrated effort, and is a credit to American science.

The subject of the investigation is a pelagic or free-swimming Ascidian, confined to the high seas, and exceptional even in a group whose larvæ are plainly allied to vertebrates, while the adults have lost nearly every resemblance to their vertebrate allies by the degeneration and loss of their vertebrate features. Salpa is aptly described by Prof. Brooks as a transparent swimming Tunicate, which in effect is "an enormous pharynx which swims through the water, gulping in great mouthfuls at each contraction of its muscles." Happily the supply of radiolarian and diatom food is unlimited, and hence Salpæ multiply in immense profusion and with astonishing rapidity.

Salpæ under favoring conditions of food, and perhaps other physical causes not discussed by the author, reproduce both sexually and asexually. Each species has two generations in its life-cycle, known as the solitary generation and the aggregated generation. Chamisso, the poet, novelist, and biologist, first discovered this. The solitary salpa is born from an egg which is carried within the body of the aggregated salpa, whose blood nourishes the embryo during its development by means of a nutritive placenta. On the other hand, the aggregated or chain salpæ are produced asexually by budding from the body of the solitary salpa.

This placenta, as Brooks shows, contrary to the views of some writers, has only a superficial resemblance to the fœtal organ of the mammals; it is an independent structure, being in the salpa only of use in conveying food to the embryo. This food has been discovered by the author to be great placenta cells which migrate from the body of the chain salpa into the body cavity of the embryo. Hence the embryo salpa stands in a much more direct relation to the external world than the mammalian embryo.

Space will not permit us to further notice the special points elaborated by the author, the table of contents alone occupying two crowded pages. The work is divided into four parts: I. A general account of the life-history of salpa. II. The systematic affinity of salpa in its relation to the conditions of primitive pelagic life; the phylogeny of the Tunicata; and the ancestry of the Chordata. III. A critical discussion of my own observations and those of other writers, on the sexual and asexual development of salpa. IV. On the eyes and subneural gland of salpa, is by M. M. Metcalf, who, among other points claims, contrary to Buetschli, that the eye of salpa is not homologous with the eye of any other chordate animal.

The general reader and biologist will be especially interested in the views presented in Part II. Brooks speaks of the wonderful scarcity of pelagic life in the lagoons and landlocked waters of the Bahamas, and explains it by the theory that the surface life is eaten up by the animals at the bottom, every organism swept in by the tides and every larva born in the sounds being eaten up by the polyps, etc., at the bottom, the competition for food being so fierce. He maintains that early in the Cambrian period, or when life first began, it was pelagic, or confined to the surface. Gradually some of the pelagic forms, at first minute and simple, settled at the bottom, and such a primitive bottom fauna was similar to the lower Cambrian fauna. This bottom fauna at first entirely depended for food upon the pelagic life at or near the surface, there being no plant life yet in existence. This primitive bottom fauna was established around elevated areas in water deep enough to be beyond the influence of the shore. He claims that the great groups of Metazoa, or all animals above protozoans, were rapidly established from pelagic ancestors. This, it may be said in passing, is in direct opposition to the view generally entertained that the pelagic fauna is derived from the shoal-water or shore life.

After the establishment of the first bottom fauna competition swiftly arose, became very rigorous, and led to rapid evolution, and "life on the bottom introduced many new opportunities for divergent modification and for the perfecting of animals." The increase in size of the animals also increased the possibilities of variation, and led to the natural selection of those peculiarities which increased the efficiency of different organs, and thus proved an important factor in the evolution of complicated organisms; the new modes of life—what they were, the author does not state, but they must have been in great part the results of fixation at the bottom, together with the operation of currents, etc.—permitting the acquisition of protective shells, or hard, supporting skeletons. Life at the bottom also introduced the factor of competition between blood relations, the fiercest competitors of each kind of animal being its closest allies, "which having the same habits, living upon the same food, and avoiding enemies in the same way, are constantly striving to hold exclusive possession of all the essentials to their life." Thus the tendency of such bottom forms was to divergent evolution of the great types of animal life. Since then, the author claims, "evolution has resulted in the elaboration and divergent specialization of the types of structure which were already established, rather than in the production of new types." This is all very likely, and, to continue the train of reasoning, the next great step was the origin of land animals, terrestrial and fresh-water arthropods, and the third great step was the evolution of animals, arthropod and vertebrate, adapted for life in the air. We may suggest that it was the Lamarckian factors of profound and widespread changes in the environment, such as a transfer of the habitat of animals from the surface to the ocean bottom which tended to increase and diversify life forms, together with the use and disuse of organs resulting from enforced adaptation to the new conditions. After all this had begun there comes in the more passive factor of natural selection, subordinate, though constantly at work, which further promoted the elaboration and specialization of organic forms.

Letters of Asa Gray. Edited by Jane Loring Gray. In Two Volumes. Boston: Houghton, Mifflin & Co. Price, $4.

Dr. Gray was a delightful correspondent. He wrote with the easy manner and hearty tone that give letters their highest charm. In telling distant friends what he

is occupied with he presents no bare outline, but fills up his picture with a wealth of interesting details. And his good-natured fun is continually peeping out from some corner. The first group of letters concern various undertakings between the twenty-first and twenty-eighth years of his life, and are mostly addressed to his father and mother and to Dr. John Torrey. In them he speaks frankly of his plans and aspirations, saying in one place, "I am determined to persevere for a little while yet before I give up all hopes from science as a pursuit for life." His journeys by stage-coach and steamboat to various places in the State of New York and one to Detroit are graphically described. His account of his first journey in Europe, given in letters home which took the form of a journal, is also very graphic. We find in the early pages of this chapter enthusiastic references to twenty days of study among Sir William Hooker's botanical collections, closely followed by a description of Edinburgh and references to lectures by the famous men in its university. Here he does not neglect to note that Dr. Hope, who lectured on chemistry, "did not wear his gown or ruffles at the wrist," also that the class in anatomy "behaved shockingly, even for medical students." In London, through his letters of introduction and the good offices of Hooker and his son "Joe," who were there at the same time, Gray made many pleasant and useful acquaintances. Busy days those spent in the "modern Babylon" must have been, for a bewildering number of persons and places were visited. Proceeding to France, Dr. Gray made the acquaintance of Jussieu, Decaisne, Seringe, Delile, and other botanists. He then crossed Italy and visited parts of Austria, turned back through Switzerland and Germany, and finally sailed from Hamburg for London. His journal describes his meeting with the celebrated botanists of all the places visited, and contains the traveler's impressions of the usual "sights," besides notes of miscellaneous incidents of travel. The year in Europe is followed by a decade of work at home, in the early part of which Dr. Gray was appointed to the Fisher professorship in Harvard College, which he retained for the rest of his life. The letters of this period speak of work on Torrey and Gray's Flora of North America, the arrangements for the new labors at Harvard, and work on various publications. One of his first discoveries in Cambridge was that "there's nothing like Down East for learned women," and he gives instances. A second trip to Europe was made in 1850–'51; old friendships were revived and new ones made. One of the new friends was Charles Darwin, and a large part of the letters in the next division of this collection were addressed to him. The letters in the remaining divisions tell of new publications and revisions of old ones, the examination of collections and single specimens from all quarters of the globe, further journeys to Europe and elsewhere, and miscellaneous matters. One of the most valuable features of these two volumes are the opinions and bits of information about prominent botanists that are scattered through them. Prof. Gray was not oblivious to affairs of moment outside the field of botany; thus his letters during the time of the civil war contain many vigorous comments upon passing events, and we are informed in a foot-note that he enlisted and drilled with a company raised for service in Massachusetts. He was then over fifty years of age. The playful turns of thought already referred to are frequent. Now the subject is the German feather-stuffed bed-covering, again it is the simian ancestry implied in Darwin's books, but nothing is more delightful than the burlesque botanical description of the piece of wedding cake that he sends to the Torreys. The two volumes contain three portraits of Dr. Gray, a picture of him in his study, and a view of the range of buildings in the Harvard Botanic Garden. A brief autobiography prefixed to the first volume gives an account of Gray's ancestry and his early years.

A Class in Geometry: Lessons in Observation and Experiment. By George Iles. New York and Chicago: E. L. Kellogg & Co. Pp. 46. Illustrated. Price, 25 cents.

"Can dry bones live?" is apt to be one's thought in taking up a book on lines, surfaces, and angles. That the dry bones of geometry *can* live Mr. Iles proved to the readers of The Popular Science Monthly in November, 1890. He then told in part a story which here is told in full. Taking an

informal class of three boys, he led them to observe their common surroundings—fields and farms, buildings and machinery, plants and insects—bringing out their embodiment of laws of form and size of the widest sweep. Breaking a live coal into fragments on a hearthstone, his pupils saw that the smaller a lump the sooner it cooled and turned black; step by step they discovered that the moon, the earth, Jupiter, and the sun, from their relative magnitudes, are in the same case—are but cinders, or cinders in the making. Simple models, easy to reproduce, served in other lessons—an inverted wedge gradually withdrawn from immersion in a jar half full of water became an extractor of square root; an inverted cone, similarly treated, was employed as an extractor of cube root. A diagram, which has only to be seen to be understood, enabled his class to perceive that the surface of a sphere is equal to the curved surface of the cylinder which incloses it, and hence is equal to the rectangle which the cylinder describes in being rolled round once on a plane. Mr. Iles abundantly exemplifies the inventiveness which he recommends as an element in making a lesson stick to a pupil's mind. On the very threshold of Euclid he has come upon novel and important implications of the elementary laws of space; he has thence opened new paths of approach to the study of mechanics and physics. A distinctly refreshing note is struck in illustrating that not the immediate but the total indications of geometry point the way to the constructor; that if calculation is to be just, it must be directed with judgment. This little book can be as helpful to the teacher as that other unconventional aid, William George Spencer's Inventional Geometry.

White's New Course in Art Instruction. Manual for the Fifth-year Grade. New York, etc.: American Book Company. Pp. 112. Price, 50 cents.

White's New Course in Art Instruction embodies the ideas of many teachers, who, starting at different points and working along different lines, arrived at the same conclusions. Its aims are, first, to acquaint pupils with the rudiments of all kinds of drawing included under the two departments, mechanical and free hand; secondly, to lead pupils to feel that, while art and love for the beautiful may be fostered by an artistic and beautiful environment, skill and power and quick original perception of beauty come only through faithful and persistent practice in drawing; and, thirdly, to develop a love for the beautiful in Nature and art. The fifth year or grammar course includes the study of measurement, geometry, writing, drawing, development, color, historic ornament, botanical drawing, design, paper-cutting, and model and object drawing. Each subject is logically pursued throughout the grade, and each subject supplements others in the grade. The book abounds in each department in practical directions, concisely and perspicuously given, to which the illustrations, clearly and accurately drawn, are a real help.

Symbolic Education. A Commentary on Froebel's Mother Play. By Susan E. Blow. New York: D. Appleton & Co., 1894. International Education Series. Pp. 251. Price, $1.50.

The advent of the kindergarten in the educational system of this country has great significance, and statistics show a steady increase in kindergartens, teachers, and pupils.

Symbolic Education, by Susan E. Blow (Appletons' International Education Series), discusses practically the foundation of Froebel's philosophy in Mother's Play and Nursery Songs.

The editor, Dr. Harris, says the kindergarten inspires its teachers with the true missionary spirit, to devote themselves to the work of unfolding the self-activity of humanity in its feeblest and most rudimentary stage of growth. The teacher of advanced pupils does not need such refinements of method to secure profitable industry—it is the teacher of feeble-minded adults, or of very young children, that must have what the Germans call a "developing method." The good kindergartner continually follows Froebel by directing the pupils' own efforts without stunting them by officious help. Mothers should take heed of the warning that over-cultivation of verbal memory cripples alike the power of original thinking and accurate observation. He says that the first self-revelation of the child is through play. He learns thus what he can do—what he can do easily at

first trial, and what by perseverance and contrivance. The child is naturally always outgrowing his playthings, always exhausting the possibilities of a given object to symbolize occupations and deeds of grown-up humanity about him. Were the child to arrest his development and linger contented over a doll or hobbyhorse, the result would be lamentable. Hence *unmaking* is as important as making, destructive energy is as essential to him as power of construction—a point often missed by kindergartners who have not penetrated Froebel's inner connection. This ideal of play material is realized in his gifts. Play must be purified by rational insight. From insight into the deep meaning that lies hid in childish play, there is but a step to its use in education. The manifold errors of kindergartners can be avoided only by clear insight into Froebel's aim—development of creative activity—and his kindergarten gifts are the practical response to the cravings of childhood. Rousseau's idea of atomism is criticised in contradistinction to *Gliedganzes*—"member whole"—man as a self-determined individual yet a constituent of a social whole. This, Dr. Harris says, "is undoubtedly the deepest and most fruitful idea in the philosophy of education, and the key to the practical work of Froebel—the source of that symbolism which is his most original contribution to educational science. . . . Rousseau's significance in education lay in opposing established institutions. He failed to see the revelation of human nature in social combination and thus missed education's chief aim. His Émile (Appletons') made educators recognize the sacredness of childhood. Its study is necessary to explain Pestalozzi, Froebel, etc."

Important considerations are offered in opposition to Rousseau's suggestions concerning exercising the senses and restraining the mind's activity. To develop quick perception, it is necessary not only to exercise the senses but to increase the pupil's stock of general ideas, and thus illuminate the mind that uses the senses. Environment and absorption of ideas from harmonious surroundings follow as important in child-education.

Pestalozzi is quoted as having struck the keynote of educational reform: "Nature develops all the powers of humanity by exercising them; they increase with use." Misuse is not use—not all exercising is developing. "The child that walks too soon deforms its legs." Exercise must be proportioned to strength to increase strength. Remarks upon education dealing with powers only as they become explicit are exceptionally strong. "Notwithstanding all that has been said and written, we still make knowledge our idol, and continue to fill the child's mind with foreign material, under the gratuitous assumption that at a later age he will be able, through some magic transubstantiation, to make it a vital part of his own thought. This is like loading his stomach with food which he can not digest under the delusive hope that he may be able to digest it when he is a man. . . . But glaring as are our sins of commission they pale before our sins of omission, for, while we are forcing upon the child's mind knowledge which has no roots in his experience, or calling on him to exercise still dormant powers, we refuse any aid to his spontaneous struggle to do and learn and be that which his stage of development demands."

This book is emphatically one for mothers, as it presents the subject of early child-training in a thoroughly practical manner.

The Psychological Review. Edited by J. McKeen Cattell and J. Mark Baldwin, with the Co-operation of Alfred Binet, John Dewey, H. H. Donaldson, G. S. Fullerton, William James, G. T. Ladd, Hugo Munsterberg, M. Allen Starr, Carl Stump, and James Sully. Published bimonthly by Macmillan & Co., New York. Pp. 112. Price, 75 cents; $4 a year.

The leading and principal article in the first number of this periodical, January, 1894, is the presidential address of Prof. George T. Ladd before the New York meeting of the American Psychological Association, in which, while the science of psychology is confessed to be embryonic in its present stage, it is claimed that more opportunity is afforded on that account for students and investigators to contribute something important to its more stable and higher evolution. Three classes of inquiries are suggested, embracing the relation in which the statistical and experimental investigations stand to the total science of psychology, the relation in which the science stands to what we call

philosophy, and the relation in which it stands to conduct and to the practical welfare of mankind. Following the discussion of these questions is the speaker's expression of the conviction that the more he studies and teaches the science the deeper the impression that it is able and destined to contribute greatly to the welfare of mankind—by contributions toward the improvement of the art and practice of teaching; to the science and practice of medicine, especially in the department of neurology; to the diagnosis and treatment of the insane, the incorrigible, and the idiotic. "In general, why should we not expect to see our science contributing to the improved conduct and character of men in the school, in the courtroom, the prison, and the asylum," to the work of the religious teacher and the mother? This address is followed by a study of the case of John Bunyan, by Josiah Royce; Studies from the Harvard Psychological Laboratory, by Hugo Munsterberg; shorter contributions on Arithmetic by Smell, by Francis Galton; The Psychology of Infant Language, by John Dewey; Work at the Yale Laboratory, by E. W. Scripture; Discussion of Works by Prof. Wundt and Mr. James Ward; and notices of psychological literature.

The Canadian Ice Age: Being Notes on the Pleistocene Geology of Canada, with Special Reference to the Life of the Period and its Climatal Conditions. By Sir J. William Dawson. Montreal: William V. Dawson; New York: Scientific Publishing Company. Pp. 301.

The subjects discussed in this book have occupied the attention of the author to a greater or less extent since 1855, and he has published from time to time several papers and one pamphlet—Notes on the Post-pliocene of Canada—upon it. The present book is an attempt to collect in a convenient form the large mass of information included in the papers bearing on the history of the northern half of the continent of North America during the Ice age. Not satisfied with undertaking to explain the widespread and complex glacial formations of Canada by one dominant cause, the author is convinced that we must take into account the agency of both land ice and sea-borne ice in many forms, along with repeated and complex elevations and depressions of large portions of the continent. He is disposed, however, to seek for the causes of changes in climate rather in geological and geographical agencies than in astronomical vicissitudes. He notes the fact that no change, even of varietal value, has taken place in species since the beginning of the Pleistocene period as one of extreme significance with reference to theories of the modification of species in geological times. While not attempting to extend his generalizations south of Canada, he warns geologists in our country who insist upon portentous accumulations of ice within its territory, "that the material can not be supplied to them from Canada. They must establish gathering grounds within their own territory."

First Lessons in Civil Government. By Jesse Macy. Boston: Ginn & Co. Pp. 229. Illustrated. Price, 70 cents.

The expansion in the sphere of government in the United States has far outstripped popular education in the duties of citizenship. This undoubtedly is one of the causes of the current failure in government, deplored in every State and Territory of the Union. Hence the incalculable value of instruction such as Prof. Macy's, which takes boys and girls just as they are and interests them in the affairs of their county and State and the nation. Our author maintains that when a child is drawing a map of its township it readily comprehends that a township elects officers and cares for the highways; so, also, when drawing a map of its county and State it can easily understand that these are not mere pieces of land, but that they represent governments as well. Beginning with the public school which a child is attending, the government of the school district is shown as linked to that of the State; next, the county governments are studied in their various forms. As typical States, Prof. Macy has selected Massachusetts, New York, Pennsylvania, and Virginia; the government of each is described, and the governments of all four are compared; provision is made for the study of any other State government. Lastly, the Government of the United States is briefly explained. Thus, with the practiced hand of a teacher for many years successful in this branch of education, Prof. Macy begins

at the home acre, that he may the better end by inculcating an intelligent patriotism which regards the whole country. In his concluding chapters he passes from exposition to appeal. He shows how much government means in modern life, and insists, none too strongly, on the necessity that government be purified. He declares that millions of citizens stand ready to die for their country who refuse to make the daily sacrifice of time and comfort demanded for the honest and competent discharge of public trusts.

Civic virtue, indeed, is no mere plaint of the moralist, it is the sole condition upon which scientific advance can come to its fruitage—upon which public health and safety can be enjoyed. America, for example, lags far behind Europe in civic engineering, simply because to extend the scope of municipal administration would but widen the field for official incapacity and corruption.

The Wilder Quarter-Century Book: Original Scientific Papers, dedicated to Prof. Burt Green Wilder. By some of his Former Students of Cornell University. Ithaca, N. Y.: Comstock Publishing Company. Pp. 493. Price, $5.

No more graceful tribute could well be conceived nor ample volume designed for the purpose intended than The Wilder Quarter-Century Book—1868–1893. In fact, seventeen of Prof. Wilder's former Cornell pupils, who have since become more or less famous in sundry scientific departments, have joined hands and pens in dedicating to their worthy professor anything but a perfunctory work. This assumes the form of a collection of papers on physiological subjects, including vertebrate zoölogy and neurology. Their dedication to Prof. Wilder, B. S., M. D., is declared as "a testimonial of their appreciation of his unselfish devotion to the university and in grateful remembrance of the inspiration of his teaching and example." The book itself is well printed and profusely illustrated, several excellent plates being noticeable throughout. A finely executed portrait of Prof. Wilder by John P. Davis, Secretary of the Society of American Wood Engravers, constitutes the frontispiece. The President of the Leland Stanford Junior University, David Starr Jordan, LL. D., contributes the first article—Temperature and Vertebræ: a Study in Evolution—which discusses with clearness the relations of the numbers of vertebræ among fishes to the temperature of water and the character of the struggle for existence. An essay by John Henry Comstock, B. S., Professor of Entomology and General Invertebrate Zoölogy in Cornell University, on the application of the theory of natural selection in the classification of animals and plants, illustrated by a study of the evolution of insects' wings, completes another important paper. The Vital Equation of the Colored Race and its Future in the United States is contributed by Dr. Rollin Corson, B. S., and Theobald Smith, Ph. B., M. D., Professor of Bacteriology and Hygiene in Columbian University, Washington, D. C., treats of the Fermentation Tube, with special reference to anaërobiosis and gas production among bacteria. Muscular Atrophy is considered as a symptom by Dr. William Krauss, B. S.; and Prof. Biggs, M. A., M. D., of Bellevue Hospital Medical College, invites the reader to a bacterial study of acute cerebral and cerebro-spinal lepto-meningitis. An interesting and important essay is that by Veranus A. Moore, B. S., M. D., of the United States Department of Agriculture, on the character of the Flagella on the Bacillus Choleræ Suis; while Grant Sherman Hopkins, D. Sc., of Cornell University, unfolds the nature of the lymphatics and enteric epithelium of *Amia calva* The instructor of vertebrate zoölogy in Cornell University, Pierre Augustine Fish, B. S., adds a highly thoughtful paper on Brain Preservation, giving a *résumé* of some old and new methods.

While other essays of import go to make up the work, the engravings of moths and some fine plates by Anna Botsford Comstock, B. S., natural-history artist, may, from an art point of view, be regarded as possessing a high order of merit. Preceding a table showing the courses given by Prof. Wilder, we obtain also an intimate acquaintance with Dr. Wilder's numerous and miscellaneous writings from 1861 to 1893. These include published works, essays, papers read, and many important reviews. The volume before us lacks nothing in completeness and the style throughout is clear, very often fascinating, and always of varying importance. Within certain limitation, the work will

serve as a valuable adjunct in every student's library.

In continuation of the archæological work of the late Prof. *Eben Norton Horsford*, his daughter, Miss *Cornelia Horsford*, has published together a paper by her father entitled *Leif's House in Vinland* and one by her on *Graves of the Northmen* (Damrell & Upham, Boston). The former describes excavations made by Prof. Horsford in Cambridge on the site of a dwelling which he identified as one built by the Norse discoverers of America, the latter describes similar excavations made by his daughter on the site of a similar dwelling near by. Among the discoveries on these spots are parts of the foundation walls, fireplaces, charcoal, shells of mollusks, and the teeth and bones of a deer. Miss Horsford has also opened two grave mounds, but has not opened what she thinks may be the grave of Thorbrand the Valiant, preferring to leave this work to an experienced archæologist.

An *Iowa Geological Survey*, apparently the third one, was organized in 1892, and has issued its *First Annual Report*. The most extended paper in this volume is a general account of the Geological Formations of Iowa, by Charles R. Keyes, the Assistant State Geologist. There is an account of Cretaceous Deposits of Woodbury and Plymouth Counties, by the State Geologist, Samuel Calvin, a Catalogue of Minerals, and papers on Limestones and Lava Flows. Ten plates and twenty-six cuts illustrate the text. A bibliography of two hundred and fifty pages included in the volume shows that its field is not an untrodden one.

Whenever a public library is started one of the first and most important tasks of its managers is to make up a list of books as the foundation of the collection. Most of the labor of this task could be saved in every case if a carefully made list were obtainable that need only be slightly changed so as to fit it to the requirements of the library in question. At the Columbian Exposition the American Library Association exhibited a popular library of five thousand volumes, in which were illustrated the most approved methods of shelving, cataloguing, and issuing books. A catalogue of this collection has been issued by the Bureau of Education, under the title *Catalog of A. L. A. Library*, and is designed to serve the purpose of a list the need of which is indicated above. The committee in charge of the work does not claim that the A. L. A. Library is an ideal selection, but that it is a good working library, and that no board of trustees would make a mistake in duplicating it. The Catalog really contains two catalogues of the books selected—one arranged according to the Decimal system, the other according to the Expansive system. The books in the classes of fiction and biography are not given in the classed catalogues, but in separate alphabetical lists. A large proportion of the books exhibited were given by their publishers. The collection was to be, and probably now has been, deposited with the Bureau of Education at Washington, for permanent exhibition. The selection of the A. L. A. Library might be criticised as better adapted to a community of students than to the users of the ordinary popular library. Seventy-five to eighty per cent of the circulation of every popular library is fiction, but only a fraction over fifteen per cent of the books in this collection is fiction. This library tries to cover all fields of knowledge fairly well, and what it shows is not so much what the average reader would want as what he ought to want.

The *Report of S. P. Langley, Secretary of the Smithsonian Institution, for the Year ending June 30, 1893*, presents briefly a general account of the Institution, and in the appendixes summaries of the reports of the officers in charge of the National Museum, the Bureau of Ethnology, the Bureau of International Exchanges, the Zoölogical Park, and the Astro-physical Observatory.

Several numbers of *Aëronautics*, a monthly journal devoted to the subject indicated by its name, have been received since last October, when it was established by M. N. Forney, publisher of the American Engineer and Railroad Journal and various engineering books (47 Cedar Street, New York, $1 a year). It is to contain in twelve numbers the papers presented to the Congress of Aërial Navigation held during the World's Fair, besides other articles, notes, comments, news, etc. Among the papers contained in the first four numbers are On the Problem of Aërial Navigation, by the

late C. W. Hastings; The Internal Work of the Wind, by Prof. S. P. Langley; and Exploration of the Upper Atmosphere, by N. de Fonvielle. A large illustration occupies the first page of each number—that in the first number shows an English military balloon, that in the second the Maxim flying machine.

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Dean, Bashford. Contributions to the Morphology of Cardoselache (Cladodus). Boston: Ginn & Co. Pp. 28, with Plates.

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POPULAR MISCELLANY.

Studies of Lakes.—Lakes, says Mr. Albert P. Brigham, belong within the domain of what is sometimes called geographical geology. Their geographical interest is not small. Their variety in size, from the smallest natural ponds up to inland seas, their diversity in shape, depth, and altitude, and their great numbers, are facts which strike the attention and suggest inquiry. Studied geologically, lakes open up an important body of facts. Primeval continents could not have progressed far in their growth before lake-making conditions began to appear. Viewed individually, lakes are affairs of short life. Geological forces are always making lake basins, and such basins are constantly being destroyed by filling with sediment, or by the cutting down of their rims; or, the basin may remain, while the lake is destroyed by desiccation. On most competent authority, the numerous lakes of the Scottish Highlands are but a fraction of what have formerly existed. The variety of forces whose action aids in bringing lakes into being has suggested the most convenient classification of lakes—that is, according to their origin. Thus we have a relatively small group of lakes of volcanic origin, occupying old craters or valleys obstructed by lava. More important is the group of orographic lakes, or those due to deformation of the earth's crust. Here belong the lakes of the Great Basin. In limestone countries, solution lakes are not uncommon, and this agency has been operative in enlarging many basins due primarily to other agencies. Landslip lakes have been noticed by Lyell, and Gilbert records the formation of small lakes behind landslip terraces. River and shore lagoons must be named in any full classification, while glaciation, in one way or another, is responsible for the existence of most lakes. Here we have the ice-dam or temporary type, as Agassiz and Iroquois, the kettle-hole group, which is often made to include what Geikie calls "Lakes of the Plains," and which he defines as lakes that "lie in hollows of the covering of detritus left on the surface of country when the ice-sheets and icebergs retreated." Thus they differ from the kettle-hole ponds, which are thought to have frequently originated by the sliding of *débris* from stranded bergs or ice masses isolated by retreat of the main sheet. Other glacial lakes are due to morainic dams in valleys, and yet others are in whole or in part rock basins, due to glacial excavation; of these are the lakes of New York.

The Beginnings of Speech.—André Lefévre, in his book on Races and Languages, postulates as the origin of speech that the animal is already in possession of the two significant elements of language: the cry, spontaneous and reflexive, of emotion and need; the cry, already intentional, of warning, menace, and appeal. From these two sorts of cry man, endowed with a richer vocal apparatus and less limited cerebral

faculties, has derived numerous varieties, by prolongation, duplication, and intonation. The cry of appeal, the germ of the demonstrative roots, prelude to nouns of number, sex, and distance; the emotional cry, of which our simple interjections are survivals, combining with the demonstratives, prepares the outlines of the proposition, and prefixes the verb and the noun of condition and action. Imitation, either direct or symbolical, but necessarily only approximative, of the sounds of Nature, or, in short, onomatopœia, furnishes the elements of attributive sorts: from which proceed the names of objects and special verbs and their derivatives. Analogy and metaphor complete the vocabulary by applying to objects of touch, sight, smell, and taste the qualifications derived from onomatopœia. Then comes reason, which, discarding the greater part of this unwieldy wealth, adopts a larger or smaller number of sounds reduced to a vague or generic sense; and by derivation, suffixing, and composition cause to proceed from these subroots indefinite lineages of words, having every manner of relationship among themselves, from the closest to the most dubious, and which grammar proceeds to distribute among the recognized categories of parts of speech.

The Audubon Monument.—The Monument in memory of J. J. Audubon, erected by the Audubon Monument Committee of the New York Academy of Sciences, consists of a granite base, a bluestone die, and a cross, and is in all twenty-five feet ten inches high. It is adorned with figures of the birds and animals which Audubon described. In raising the money for it, Prof. Thomas Egleston says, at first school children took a great interest in it individually, and many subscriptions were received from schools as the contributions of the children. Some subscriptions were sent in postage stamps, others as low as ten cents were received from every part of the United States. After a number of months it was found that by this method a sufficient sum for the erection of the monument could not be raised. It was then proposed to ask a hundred gentlemen in the cities near New York in which Audubon had been especially interested to give a hundred dollars each, and this plan succeeded so well that the amount was raised in the fall of 1891. The contributions for the monument were received from almost every part of the United States. Boston was very liberal; Philadelphia and Baltimore made some subscriptions; but much the largest part was contributed by citizens of New York city. The small balance which remains is to be invested as "the Audubon Publication Fund," the interest of which is to be devoted to the publication of a memoir on some zoölogical or botanical topic, annually, or whenever a paper suitable for such memoir shall be presented.

Experiments with Liquid Oxygen.—By means of the intense cold produced in his experiments in liquefying gases, combined with an exhaustion not before attained, Prof. Dewar has proved that mercury distills, as do phosphorus and sulphur, at the ordinary temperature when the vapor pressure is under the millionth of an atmosphere. The increasing indisposition shown by the chemical elements to combine with one another as the absolute zero is approached was well illustrated in an experiment in which liquid oxygen was cooled to — 200° C. On inserting a glowing piece of wood into the vessel above the liquid it refused to burst into flame. Another interesting experiment was that of immersing an electric pile composed of carbon and sodium into liquid oxygen; almost immediately the electric current ceased, in consequence of the suspension of chemical action. Absolute alcohol, run upon the surface of liquid air, after rolling about in the spheroidal state, suddenly solidifies into a hard, transparent ice, which rattles on the sides of the vacuum test-tube like marble. On lifting the solid alcohol out by means of a looped wire the application of the flame of a Bunsen burner will not ignite it. After a time the solid melts and falls from the looped wire like thick sirup.

Mountains and Lakes.—The first of Sir Douglas Freshfield's Christmas lectures before the Royal Geographical Society was on mountains in their relation to the earth as a whole, and more particularly the peculiar features of snow mountains. Mountains, however great in human eyes, the lecturer said, were mere wrinkles on the face of the earth. How were they made? was a natural

question for a child to ask, but one which men of science hesitated in answering. When did the moraines come that rise like railroad embankments among the orchards and corn-fields of Savoyard valleys? Was their material excavated by the moving ice, or did the ice serve as a sledge to transport the rocks that fell from the peaks and ridges around them? The matter was one capable of direct observation. It was not the largest glaciers that had the greatest moraines, but rather those that lay under lofty ridges, and particularly those where the surrounding rocks were specially subject to disintegration by weather. He agreed with those who regarded glaciers as polishers rather than diggers, and drew a distinction between abrasion and erosion. The formation of lake basins could be accounted for without the agency of ice. In fact, lake basins did not occur where they ought to, if the theory of formation by erosion was correct. Alpine towns occupied basins which had not been dug out by glaciers, but preserved by a frozen covering from being filled up by the action of torrents. Snow and ice protected the ground they covered from disintegration by ice and floods. At the same time subglacial torrents performed singular feats in cutting deep and narrow rock channels, and thus contributed to the soil they carried. The color of their water was, however, mainly due to the fineness of the particles of the mud derived from the grinding of the bowlders subjected to the glacier mill. In winter the water that flowed out of a glacier was clear. It was supplied, not as had been supposed, by the continual melting of the ice, but was the issue of subterranean springs in the glacier's bed.

Running Amok.—The condition under which the Malays run *amok*, as described by Dr. Ellis, of the Government Hospital, Singapore, in the Journal of Mental Science, seems usually to be preceded by a period of mental depression, sometimes with suspicion, and the patient, when he breaks out, slashes at, stabs, and sometimes mutilates all who come in his way, irrespective of creed or nationality. The weapons used are a short spear, a Malay *kris*, or a chopper, and in the old days—even now in the uncivilized parts of the peninsula—it was the custom to have long, forked sticks, which were used against the man who was running *amok*, to stop him and pin him to the ground. Such men, when caught, are now tried regularly and sent to an asylum; but formerly little mercy was shown them, and they were killed at once, as though they were mad dogs. The condition seems to resemble in many particulars the automatic condition which is sometimes left after an epileptic fit; this, in some cases, takes the form of running, or "procursive epilepsy"; and, if we imagine such a patient armed with a knife and imbued with a homicidal impulse, we have practically all the conditions necessary for the Malayan pathological development. The Malayan, in his sound state, professes to have no recollection of the assaults he has committed. The condition of running *amok* is becoming less common than it was a few years ago.

Leaves and Rain.—Mr. E. Stahl, says Garden and Forest, has been making a study of leaf-forms in relation to the rainfall, chiefly in the Botanic Gardens of Buitenzorg, and he says that while a large leaf-surface partly provides for the removal of water by transpiration, there are other distinct methods by which plants are helped to dispose of any excess of water accumulating upon them as speedily as possible. One of these is the adoption of the sleeping position by leaves, such as those of the sensitive plant, so that when the horizontal leaves bend upward the raindrops run off by the base of the leaf. Most frequently, however, excessive moisture is drained off by long points to the leaves. These points occur on the lobes of divided leaves, but are most remarkable on long ovate leaves. In some plants the prolonged midrib has the form of a wide channel, but generally it is that of a tapering and narrow point, slightly curved ot the end. As the water trickles down the inclined narrow points it passes from the upper to the under surface before dropping from the leaf, and the bent tip accelerates this action. Stahl tested this theory by experiments, and found that the leaves of *Justicia picta* which he carefully rounded retained moisture for an hour, while those with the dropping points left on were dry in twenty minutes or less. This rapid remova of water from the leaf lightens its weight,

helps transpiration, and cleanses the surface. In verification of this we are reminded that after a shower the pointed leaves of the ash, willow, etc., have had the dust quite washed out, while rounded leaves like those of the oak are still dirty.

Timber Testing.—From the Report of the Division of Forestry for 1893 we learn that the scheme of testing timbers to determine their several qualities has found general favor in this country and in the Old World too. The calls for special investigations into the qualities of various kinds of timbers have been numerous, and beyond the financial ability of the division to attend to them all. A special demand exists for the tests of kinds that are still more or less unknown, they being now drawn upon to eke out the deficiency of supply of the better-known kinds. The collections of test material had reached, at the time of preparing the report, a total of two hundred and thirty-four trees. A series of tests and examinations of bled and unbled timber has been carried on in order to ascertain whether the practice of taking the resin from trees has any influence on its quality. The results seem to show that there is no determinable influence upon the mechanical properties of the timber. But the removal of the resin, if not carried on with care, affects the life of the tree and invites other destructive influences. The turpentine industry, like the lumber industry, is carried on on the "robbing system" of taking off in the most crude and rapacious manner what Nature has provided. It is time, Prof. Fernow maintains, to substitute a "management system," which shall utilize the remaining resources more exhaustively yet more carefully, by avoiding all unnecessary waste.

Madagascar Lemurs.—The great island of Madagascar, with a surface extent exceeding that of Italy, is, like Australia, a land by itself, with a fauna distinct from that of Africa. This fauna is particularly characterized by the presence of numerous lemurians or *maki* mammals, which are also called false monkeys, or fox-nosed monkeys, and which occupy a corresponding place with the monkeys of Africa. A few lemurians are found in Africa and Malaysia, but they appear to be isolated there, and like estrays among a fauna of different character. There still exists on this island a singular cat called the *Cryptoproctus*, which is plantigrade (sole-walking), while all the other cats in the world, excepting Australia, are digitigrade (toe-walking). Such zoölogical peculiarities give this island as nearly a marked stamp of strangeness as that by which Australia is distinguished. To find a fauna comparable to this we have to go back to the ancient geological periods and question the fauna characterizing them. We find that animals similar to those living in Madagascar inhabited the forests of France in the Eocene and Miocene ages of the Tertiary. Vestiges of an animal but little different from the *Cryptoproctus* of Madagascar have been found in these formations, and the remains of tree-living lemurians allied to the *makis* of Madagascar have likewise been found in them. Thus Madagascar yet supports a Tertiary fauna, as Australia is still the home of a Cretaceous fauna. The investigation of the fossil fauna of the country becomes, in the light of these facts, a matter of much interest. It has hardly been begun as yet, but has yielded some remarkable specimens. Among them are the eggs and bones of the largest of all the birds known—the *Epiornis*, sixteen feet high—a hippopotamus very different from those now living, and the skull of a great lemurian which has been described by Mr. Forsyth Major as *Megaladapis madagascariensis*. The lemurians now living in Madagascar are only of medium size or small. The largest of them is the short-tailed *indri*, which is but little more than three feet high when standing erect on its hind legs. The *Megaladapis* was three times as large, or about the size of the orang-outang or the gorilla.

Mrs. Hemenway's Work for Science.—Mrs. Mary Tileston Hemenway, who died in Boston March 6th, seventy-two years of age, was equally famous for her benevolence and for her practical interest in promoting scientific work. Possessed of a fortune now valued at $15,000,000, she contributed half of the $200,000 that were raised to save the old South Church from destruction; projected an institute for the encouragement of the study of American history among young peo-

ple, of which Mr. John Fiske was for several years a principal lecturer; established a school for poor whites at Wilmington, N. C.; contributed to the support of the Hampton School, and founded a school at Norfolk, Va.; maintained sewing and cooking schools and schools of gymnastics in Boston; kept the Hemenway exploring and archæological expeditions at work in Arizona and New Mexico, which have borne fruit in the admirable researches of Mr. Cushing, Mr. Bandelier, and others; and was a liberal contributor to the funds of the American Archæological Institute, and patroness of Dr. J. Walter Fewkes's Journal of American Ethnology and Archæology. By her will the net income of her estate, after certain specified payments are made, is to be appropriated for fifteen years to the support and furtherance of the objects in which she was interested. Persons engaged in archæological work at her expense are to be continued in it, as long as the results warrant it, on the same terms. At the end of fifteen years her collections—archæological, historical, and educational—are to be disposed of at the discretion of her executors. Among the specific bequests is that of the Lowry farm, adjoining the Hemenway farm, Virginia, to the Hampton Institute.

Herr Lilienthal's Flying Machine.—A communication from Prof. Du Bois-Reymond to the Physical Society of Berlin concerning Herr Lilienthal's experiments in aviation relates that in studying the flight of birds that gentleman perceived that flight was possible under conditions when the wind gave a vertical component. Experiments have shown that surfaces may acquire a horizontal motion under the action of the wind alone, provided their curvature is in a relation to the surface that corresponds exactly with that observed in birds. Herr Lilienthal's flying machine consists of a surface of suitable curvature, measuring fourteen square metres, and made of canvas stretched over a light wooden frame. At the center is an opening for the body of the experimenter, who keeps the apparatus up by working his arms. The author had seen Herr Lilienthal fly with his apparatus about one hundred and twenty metres a minute at thirty metres above the ground. With a favorable wind the experimenter could fly two hundred or three hundred metres; and Prof. Du Bois-Reymond had himself flown twenty or thirty metres with it. In the author's view the definitive solution of the question of flying machines depends upon three points—viz., judicious utilization of the wind, suitable form of surface, and skillful handling of the apparatus.

Odd Barometers.—Two of the oldest and oddest forms of popular barometers, says a writer in the London Spectator, are the leech in a bottle and a frog on a ladder. Mr. Richard Inwards has seen an old Spanish drawing of nine positions of the leech, with verses describing its attitude and behavior before different kinds of weather. Dr. Merryweather, of Whitby, contrived an apparatus by which one of twelve leeches confined in bottles rang a bell when a "tempest" was expected. When leeches were kept in every chemist's shop, and often in private houses, their behavior was the subject of constant observation; and it was generally noticed that in still weather, dry or wet, they remained at the bottom, but rose, often as much as twenty-four hours in advance, before a change; and, in case of a thunderstorm, rose very quickly to the surface, descending when it was past. The frog barometer, used in Germany and Switzerland, is a very simple apparatus, consisting of a jar of water, a frog, and a little wooden step-ladder. If the frog comes out and sits on the steps, rain is expected. The weather-glass dearest to the old-fashioned cottage in the last generation was the "old man and old woman," who came out of their rough-cast cottage in foul or fair weather respectively. This was almost the earliest of semi-scientific toys, and depended on the contracting of a piece of catgut fastened to a lever. The belief that bees will not fly before a shower is probably true, and is the rational origin of the banging of trays and iron pots with a door-key when bees are going to swarm. The insects are supposed to take this for thunder, and so settle close at hand, instead of swarming at a distance. Squirting water on them with a garden syringe often makes them settle at once. But no such ingenious process of rationalizing can be found for the belief that if the insect inside cuckoo-spit lies head upward, the summer will be dry, though the

increased worrying of horses by flies before rain, and the rise of the gossamer before fine weather, are abundantly confirmed by observation.

Habits of Birds.—Many interesting notices, local and general, respecting birds are to be found in the Abstract of the Proceedings of the Linnæan Society of New York for the year ending March 1, 1893. Frank M. Chapman, reporting at one of the meetings on the summer bird life of New York and vicinity, said that 127 species might be classed as summer residents, of which 108 were land birds and 19 water birds; 22 species might be considered abundant, 47 common, 31 tolerably common, and 27 rare. Dr. C. S. Allen contributed at another meeting an account of a breeding-place of pelicans on an island of Florida, a hundred and fifty feet long by fifty feet broad, and covered with a dense growth of mangroves. The nests were in bushes, ten or fifteen feet from the ground, were made of sticks, straw, dry weeds, etc., and held from one to four eggs. The young, on emerging from the shell, are of a size corresponding with that of the egg, and slate-colored, from tint of skin, with apparently scattering hairs (casings) protecting white down; but in a few hours they appear to have increased to several times the bulk of the egg, and become white as soon as the down is freed from the protective covering; in a few days they are as large proportionately as birds usually are when a week or two old. The increase in size is due, in part, to the power the birds have of taking air into the spaces beneath the skin which is very loose and capable of being immensely inflated. They remained in the nest only a few days, and thereafter rested on the surrounding bushes. Mr. Chapman instanced a number of cases of protective coloration, notably that of a flock of parrots flying into a palm tree, whereupon they became almost indistinguishable from their surroundings, although not hidden to any extent by the foliage. He described, as illustrating the fact of the bird's consciousness of its protective coloration, the habit the Cuban meadow lark has of turning its back to the observer, and also the instance related by Mr. W. H. Hudson, in his Argentine Ornithology, of a wounded bittern which persisted in turning its breast toward its captor, although he endeavored to pass around behind it. The bird, with its slender neck pointing straight upward, could not be distinguished from a seed stalk, except on close scrutiny. Mr. Chapman said that Dr. John A. Wells, of Englewood, N. J., had recently watched a woodcock on her nest, and was fully convinced that she was aware of her resemblance to the surroundings, for she remained perfectly quiet and allowed of a very near approach; but when a fall of snow came, and Dr. Wells again visited the sitting bird—now a very conspicuous object—she flew before he had approached within gunshot. The most notable example of protective mimicry is the European cuckoo, which, by reason of its striking resemblance to a hawk, is able to deposit its eggs in the nests of other birds, while they chatter and scold at a respectful distance. Together with many other notices of this kind, the Abstract of Proceedings contains a paper by Tappan Adney giving a list of bird names, etc., of the Milicete Indians of the St. John Valley, New Brunswick.

Measuring the Heights of Clouds.—Four methods of measuring cloud heights have been used at Blue Hill Observatory, Massachusetts: 1. The bases of the lowest clouds frequently float below the summit of the hill (one hundred and twenty-six metres above the general surface of the surrounding land), and the altitude of the base can be ascertained by walking down the side of the hill. 2. Measurements of the angular altitude of the light reflected from clouds floating over adjacent cities can be used for determining the height of the clouds. 3. The shadows of detached clouds can be seen from Blue Hill for many miles moving across the surface of the country, and, by timing the movements of the shadows between points whose distance apart is known, the velocity of the cloud can be ascertained. From the actual velocity and the angular velocity of the cloud its height can be determined. 4. Simultaneous angular measurements of the altitude and direction of the same cloud-point have been made at two stations eleven hundred and seventy-eight metres apart. An attempt has also been made to determine the height

of low clouds by the difference in relative velocity between observations at the base and summit of Blue Hill, but the difference in height (one hundred and twenty-six metres) was found too short for this purpose. The four different methods mentioned to a large extent supplement one another.

NOTES.

The rare instance of the coming of age of a whole trio of triplets was celebrated recently at Whitenast, near Leamington, England. Generally, in case of triplets, the children die soon after birth, but occasionally they survive and reach maturity. One case is on record of quadruplets, all of whom were reared.

Attention has been called to the cheapness of life in Italy by the light sentence of a few years' imprisonment recently imposed upon a native who, in a fit of jealousy, murdered a physician innocent of all offense. Jealousy is practically accepted by Italian juries as a part expiation of crime, and their misled verdicts are styled verdicts of the heart. Consequently, Italy heads the list of European countries for homicides, and the *vendetta* flourishes there unchecked. A story is told of a Neapolitan who, wishing to kill his wife, would not venture upon the act at home, where he might be guillotined, but removed to Florence, where the penalty was imprisonment for life. Since then imprisonment has been made the penalty throughout the country.

Novel uses said to have been found for aluminum are for a folding pocket scale, one metre long; a necktie made of metal, frosted or otherwise ornamented, in various shapes imitating the ordinary silk or satin article, which is recommended for summer wear; and military helmets.

A large trade, according to Mr. John Wallace, is done in the shipment from Washington ports of salmon frozen solid and packed tightly in refrigerator cars in sawdust, without ice. The cars are first reduced in temperature as low as possible, and the floors are covered with *chilled* sawdust. The boxes of fish are next placed therein, any spaces between them being filled with the cold sawdust. The car is then closed and sealed, and in reasonably warm weather its contents may be relied upon to arrive at their destination in the most perfect condition after a passage of eighteen days or thereabouts.

The mean cloud velocities at Blue Hill, Mass., indicate that the entire atmosphere, from the lowest to the highest cloud level, moves almost twice as fast in winter as in summer. The mean velocity of the highest clouds in winter is more than fifty metres per second, or a hundred miles an hour; and the highest velocity, a hundred and three metres per second, or two hundred and thirty miles per hour, show that the upper currents sometimes move with enormous rapidity.

There was a discussion once in The Popular Science Monthly regarding the position assumed by flamingoes in incubating—some authors affirming that they straddled their raised nests, their legs dangling down on either side, and others that they disposed of their legs in some other way. The question seems now to be settled by Abel Chapman, in his book, Wild Spain, who observed them in their nesting grounds on a low mud island of the Andalusian *marisma*, "most distinctly" from a distance of about seventy yards—"the long red legs doubled under their bodies, the knees projecting as far as or beyond the tail, and their graceful necks neatly curled away among their back feathers, with their heads resting on their breasts —all these points were unmistakable."

The Dutch, desiring to utilize their windmills and at the same time place them in line with the latest improvements in the applications of power, have offered, through the Haarlem Society for the Encouragement of Industry, a prize of $150 to the author of the best essay on the production of electricity through their agency.

A substitution of camels as working animals for horses and oxen has been going on for a few years past in several provinces of Russia, and they are now common on many large estates and on smaller properties. They perform all the work in farming for which horses and oxen are used, as well as being efficient in transportation. A camel market has grown up at Orenburg, and the animals bring sixty or seventy rubles, or about thirty-five dollars, delivered at Kiev.

The Baluban tribe of Central Africa are famous for their skill in casting and forging iron. They construct tall cylindro-conical furnaces of clay with tuyères of clay and an ingeniously devised wooden bellows. They make arms for hunting and for war, and collars and bracelets of iron. The neighboring natives resort to them in great numbers to exchange their own products for the manufactures of the Balubans.

More than three hundred species of fish hitherto unknown to naturalists are described by M. Léon Vaillant as inhabiting the lakes of Borneo. Many other fish are identical with species living in the waters of the Sunda Islands and of Indo-China. As these species never reach the sea, they furnish another argument in favor of the theory of a former connection of these countries.

Prof. Eugene Smith, State Geologist, shows in a paper on the Clays of Alabama,

read before the Industrial and Scientific Society of that State, that besides its riches of coal and iron, the State has clays of quality suitable for the manufacture of every kind of brick and stoneware. They are not yet developed, for want of skilled and experienced workmen, and because the world is not acquainted with their qualities. The different clays and their location are fully described in the paper.

The Arago prize of the French Academy of Sciences has been awarded to Prof. Barnard and Prof. Asaph Hall.

The Geological and Natural History Survey of Minnesota has begun the publication of bulletins embodying from time to time such discoveries as may be made or scientific contributions presented as they occur, without waiting for the slower publication of the formal reports. The first of the series of botanical studies, Bulletin No. 9, contains five papers of interest in that branch of the survey. The Bulletin will be continued in occasional parts till a volume is completed.

OBITUARY NOTES.

Colonel Alfred Burdon Ellis, commander of the successful British expedition against the Sofas in Africa and a valued contributor to The Popular Science Monthly, died at Teneriffe, March 5th, of African fever. He was the only surviving son of the late Lieutenant-General Sir Samuel Burdon Ellis, and was born in 1852. He entered the British army in 1872, and became a captain in the First West India Regiment in 1879, major in 1884, and lieutenant-colonel in 1891. During twenty-two years he saw a great deal of active service in Africa. He served in the Ashantee war and received a medal; commanded the Houssa Constabulary in 1878; was employed in the Intelligence Department during the Zulu war; was the leader of the expeditions to Tambi (Sierra Leone) and Toniataber (Gambia) in 1892, and for the latter received a medal with clasps; was civil commandant of Sekondi and Chamer on the Gold Coast in 1874, district commander of Quittah in 1878, and of Accra in 1879; was chief officer of the troops on the Gold Coast in 1882 and 1886; and was commandant in the Bahamas in 1889 to 1891, when he was appointed to the command of the troops in West Africa, with the local rank of colonel. In 1892 he administered the government of Sierra Leone. The last of his dispatches concerning the expedition against the Sofas was dated January 29, 1894. A few days after his return to Sierra Leone from this expedition he was attacked with fever, and was removed to Teneriffe. He was the author of A History of the Gold Coast, The Ewe-speaking Peoples of the Gold Coast of West Africa, The Tshi-speaking Peoples of the Slave Coast of West Africa, and of the following articles in The Popular Science Monthly: A Letter on the Lucayan Indians, vol. xxxvi; The Indwelling Spirits of Men, vol. xxxvi; On Vodu-worship, vol. xxxviii; Survivals from Marriage by Capture, vol. xxxix; On Polyandry, vol. xxxix; The Great Earthquake of Port Royal, vol. xl; Marriage and Kinship among the Ancient Israelites, vol. xlii; and White Slaves and Bond Servants in the Plantations; besides which we have others on hand awaiting publication.

Dr. H. C. Georges Pouchet, Professor of Comparative Anatomy in the Museum of Natural History, Paris, died March 29th in that city. He was the son of the Félix Pouchet who distinguished himself several years ago in the controversy respecting spontaneous generation, and was born in Rouen in 1833. He became assistant naturalist and head of the anatomical department in 1865. He was retired in 1869 in consequence of the publication of some article relating to the Museum of the School of Agronomy, but was raised in 1875 to the position he occupied at the time of his death, succeeding Paul Bert. He was the author of numerous works of scientific value, among which were his doctor's thesis on the Coloration of the Epidermis and his *Traité d'Ostéologie comparé*. He was also a writer in literature of considerable productiveness and high reputation.

Mr. William Pengelly, F. R. S., who recently died in England, was a local geologist of much and excellent reputation. He contributed greatly by the results of his personal researches to the work of Lyell, Murchison, and others in establishing English geology. He continued the exploration of Kent's Cavern, under the direction of the British Association, through sixteen years. Besides many other geological papers, he prepared, in connection with Dr. Oswald Heer, a monograph on The Lignite Formation of Bovey Tracey, Devonshire. He collected and arranged the Devonian fossils of the Pengelly Collection, now at Oxford. He originated the Torquay Natural History Society, and in 1862 founded the Devonshire Association for the Advancement of Science, Literature, and Art. He was Fellow of the Royal and Geological Societies, and an honorary member of the Société d'Anthropologie of Paris.

Paul Jablochkoff, a distinguished Russian electrician and inventor of the electric lamp which bears his name, died in Saratov, Russia, early in April. He was an officer in the Russian army, and was the first person who succeeded in dividing the electric current satisfactorily. His system of electric lighting has been used in several cities of Europe, and for a considerable time the great thoroughfares of Paris, near the Opera, were illuminated with his carbons.

HEINRICH HERTZ.

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THE MEANING OF CORPORATIONS AND TRUSTS.

By LOGAN G. McPHERSON.

TO arrive at an understanding of that tendency toward combination which is a most conspicuous phenomenon of the industrial life of the United States, it is necessary to trace the industrial development throughout its several stages. And as it has been in this country that industrial activity has met with the least hindrance, the steps of its development can be rapidly summarized with approximate accuracy. Although the industrial structures of other countries in previous centuries have had an influence in determining the industrial forms of the United States, the isolation of the American continent and the peculiarity of the conditions affecting its settlement justify the consideration of its industrial expansion as a separate growth, without reference to the industrial status of other countries or older civilizations.

Grandfathers of to-day tell us that in their boyhood in many parts of the country the life of each household was sufficient unto itself. Buildings were erected, grain was raised, winnowed, and ground; cattle were killed, their meat cured and hides tanned; wool was clipped and spun by its members, who, in addition to the performance of manifold other simpler functions, carried processes of manufacture still further—the men, in the days of winter, making the family's shoes and the women its clothes. In doing this work the members of the family were maintaining themselves in that condition which contrasted with barbarism. Houses and clothing were necessary as protection against the often inclement weather, and the possession of a regular supply of food was only possible by the preparation and preservation of the products of the recurring seasons. Upon the evenness of the

temperature of the body, secured by the use of houses and clothing, and the evenness of the vital processes consequent upon regular nutrition, depends that appreciation of the impressions which come through the senses that leads to the clear and vigorous working of the mind. But in those early days tools and appliances were so rude and methods so crude that there was little time for any one to spend except at the work which directly concerned his bodily welfare. The duration of such tasks for men and women was usually from daylight until dark. The self-sufficiency of each household was forced by the conditions of life in a sparsely settled region.

As the number of inhabitants in a certain area increased, and communication between them became less difficult, it was found that the production of certain articles, which involved particular skill, particular training, or particular facilities, could, with profit to an entire community, be left to the individuals possessing the requisite skill, training, or facilities. For example, a man making shoes for a considerable number of people acquired skill enabling him to make better shoes than the man who devoted but limited time to the making of a limited number for his own family, and the greater the time devoted to and the greater the revenue derived from the prosecution of a single industry the more readily could he afford, from time to time, to possess himself of appliances rendering more and better work possible with less effort, and the better could he afford to give more time to seeking the material best adapted for his product, which, as the quantities he used increased, he could secure, other things equal, at decreasing cost. And so with other functions contributing to material welfare.

When the demands upon an artisan became so great that he could not meet them entirely by his own personal exertion he employed a man to assist him. This is the first combination—the simplest industrial organization. Its characteristics should be carefully noted. The efforts of both men being directed by the employer, there is centralized control, and the joint efforts of the two men supplying a greater demand than was possible for the one, the field of their operations extends. And the two men, by systematically combining their efforts, other things being equal, accomplish more than could the two men working separately; wherefore, there is economy of production.

The numbers of individuals engaged in work for which there was greatest demand increased most rapidly—every village possessing its cobblers, carpenters, blacksmiths, and weavers—and with the further increase of population and the extension of the area over which their products or services could be distributed, the number of separate vocations increased. Because of the greater number of people wanting houses it became profitable for

a carpenter to make a specialty of house-building; as furniture was needed, another carpenter devoted his time to making chairs and tables. Likewise the weaver differentiated into the maker of carpets and the maker of cloths for wear; and as the village grew there evolved the tinner, the harness-maker, and so on. The followers of each vocation thrived because the members of the community found it more economical to purchase their better products than to make similar articles themselves. This differentiation or diversification of industries heightened the contrast between the life of the community and barbarism, or, in other words, increased the degree of its civilization because, by reason of the particular skill, training, and facilities of the various individuals who ministered to their various wants, the members of the community became better housed, better clothed, better supplied with the conveniences that contributed to the more rapid and efficient performance of their work and to the comfort of their homes.

The demand for a particular kind of work brought an increase in the number of individuals engaged in that work by causing an established artisan to increase the number of his employees, or by bringing an increasing number of men into that line of industry, some of whom continued to work separately, the direct servants of their patrons, while others formed other organizations of employer and employee or employees. And thus arose competition, members of a community patronizing this or that tradesman or artisan in preference to another as the quality of his work or merchandise, his prices or accessibility, were the more suitable. Competition tended to secure to the members of a community a share of the benefit of the decreasing cost of production, different producers vying with each other to retain or increase their custom either by bettering the quality of their articles or decreasing the price, or both. With increasing ease of communication there was increased competition, artisans, in the course of their work, going more readily from one place to another, and merchantable articles were distributed throughout an extending territory.

With increasing ease of communication and transportation the localization of production was also affected. While many kinds of production remained tolerably evenly diffused over extensive areas, that which depended upon extremely favorable conditions tended to concentrate at localities so favored. For example, in soil especially adapted for grazing, a farmer ceased to plant wheat when he could obtain the wheat more cheaply by purchase from a distant farmer, to whom he could sell the flesh and hides of cattle raised on his meadows. And workmen engaged in preparing the products of cattle tended to concentrate near the grazing regions, while millers would erect their mills near the wheat

fields—all classes profiting by the economy incident to production in the especially favored localities.

With increasing demand for all kinds of products, men of shrewdness to see and ability to grasp larger opportunities enlisted to a greater extent the co-operation of others by the payment of wages or the forming of partnerships. Such co-ordination afforded means for securing in a greater degree the advantages gained by the simpler combinations. For, as the artisan devoting his time to one kind of work tended to acquire the skill, appliances, and the material best adapted thereto; as, under the simplest combination—an organization of two men—these advantages were heightened; he who on a larger scale directed the efforts of others could, by careful training, develop further increase of skill, could because of a larger revenue afford to secure appliances increasing in number and cost, could procure greater quantities of the best adapted material at a decreasing price, and could devote greater energy to multiplying the consumption of his products by increasing their sale in old and extending their use in new markets. And these factors, stimulated by competition, all tend toward economy of production, to the serving of a community increasing both in extent and population with better articles at less expense. Contributing to this result was not only the economy in the immediate production of articles for immediate personal use and consumption, but the economy in the production of material and appliances used in the production of these articles.

With industrial combination and recombination an increase of capital is required for the maintenance of the larger sphere of operation. Such capital necessarily is obtained from the accumulation of those directly in conduct of the operations or from the accumulation of others. The first artisans, as a rule, doubtless obtained by their own exertions the few rude tools and appliances used in their vocations, but in the succeeding combinations funds are contributed by partners, one or more of whom may not be directly or actively engaged in the conduct of the business, in which case the active partner or partners, while benefiting by the use of the contributed capital themselves, also assume a trust, in the ethical sense of the word, for the benefit of the others. Or included in the capital may be the funds of widows and minors, which those in the active conduct of the business therefore hold in trust. When the field of operations so extends as to necessitate plant and appliances more extensive than can be provided except by contributions from the accumulations of a considerable number of persons, there arises a new form of organization—the corporation. The ownership of the various contributions to the capital fund is vouched by certificates of stock. The corporation, therefore, benefits the community as a whole, in that it commands

to a greater degree the factors that tend toward economy of production; in that it directs to greater advantage the efforts of a greater number of workers; in that it permits the attainment of profit upon their accumulations by those that contribute to its capital. As these stockholders may be of all ages and sexes, and oftentimes of residence remote from the scene of operation, those chosen to administer the capital, to conduct the operations, assume a trust of great responsibility. It is essential that control be centralized in their hands; for to the utmost rendering of this trust is necessary the most prudent administration of the capital, the exercise of the greatest discretion in the maintenance, repair, and renewal of the plant and appliances, the most efficient direction of the workers, and the most judicious distribution of the product. These results can not be obtained by scattered responsibility and scattered authority.

It is important to note that along with the development of more comprehensive organizations has been the development of the capacity to control such organizations, men of foresight and executive ability, shrewd and resourceful in the attainment and use of money, oftentimes gaining the control of extended operations over a considerable area that, in their absence, would have been conducted by simpler, separate, and scattered organizations. Not only the opportunity for increased revenue, but the ambition of such men to exercise the power incident to the control of extended organizations, is no small factor in their formation.

The great advance in the bending of physical forces to man's aid that began in the early half of this century has caused so many changes in the methods of production and distribution that it seems as though the industrial processes had undergone a radical transformation. But with the settling of the disturbed elements into definite shape it can be perceived that the seemingly newer forms are but the more compact and comprehensive expression of the old; that they are but successive steps in the series of that development which tends toward the betterment of material, economy of production, extension of distribution, and decrease of cost. The use of steam made possible the railways, in the building and operation of which is necessary the co-operation of large numbers of men working under centralized control, and, in connection with the multiplied uses of machinery, has brought the large factories and mills in which great numbers of men work under control likewise centralized. And the ease and rapidity of communication and transportation afforded by the railroad and telegraph have tended still more to concentrate particular industries in localities where conditions are most favorable to their prosecution. All these factors have allied in cheapening production, in serving a community, increasing both in extent and population,

with better articles at less expense. And they have intensified competition, the railways bringing to a community similar products from factories situated remote from each other, in many instances placing the output of each center of production of certain merchandise in competition in all parts of the United States with the output of each other center of production of that kind of merchandise. Contributing to this result have been the efforts of the salesmen of the different establishments, who, in the desire to extend the sale of their products, have underbid their competitors, who, in turn, have been obliged to lower their prices, this rivalry usually continuing until the selling price has been lowered to and sometimes below the actual cost of production. This competition is beneficial to a community as a whole so long as it compels all the processes of an industry to be conducted with thrift; and it has been beneficial when it has forced at places the cessation of certain production that could not withstand the pressure of competition of similar production from localities more favorably conditioned. But it has been injurious when, after forcing producers in most favored localities to the adoption of every reasonable economy, it has compelled them to dispose of their products at unremunerative prices. It has been injurious when many producers, each striving to dispose of the greatest possible output, have placed upon the market products far in excess of the quantity for which there is a natural and wholesome demand, thereby oftentimes forcing stoppage of production, depriving men of work until the excess is consumed, and oftentimes leading salesmen to persuade unwary merchants to make purchases so large that they are crushed beneath their weight, or tempted to defraud their creditors out of payment therefor. It has been injurious when the strife for the disposition of products has become so fierce that the energies of producers have been absorbed in fighting competition, to the neglect of the orderly and equitable administration of the vital details of production; when it has led them to make misrepresentations as to the quality of their products; when, in the desire to produce cheap articles, it has led to the adulteration of material and scrubby workmanship. It has been injurious when it has reduced the wages of employees to a point inadequate to the support of themselves and their families. Misrepresentation, adulteration, and inferior workmanship have often proceeded from cupidity and lack of scruple, but unrestrained competition feeds their noxious growth.

As with all things else, industrial competition, when carried to the extreme, meets opposing forces that bring reaction, and, as with all things else, the play of mutually opposing forces tends toward equilibrium. Equilibrium between the forces that affect industrial competition is that condition under which industrial

products are sold at prices that are fair to producers and to consumers alike.

When any industry falls into the deplorable condition brought by extreme competition, what recourse is there but for the producers to meet and endeavor to agree upon a course that will permit the attainment of remunerative prices by all; that will lead to the production of only so much output as, according to their combined judgment, can be absorbed without strain to either producer or consumer, to the abandonment of needless and excessive expenditure for solicitation, and to the sale of products only to reputable merchants of sound credit? Such conferences have led to compacts of various kinds, that usually have been but of short duration. The temptation to extend sales by a stealthy cut from the agreed price is too strong to be resisted, and the abandonment of the agreement quickly follows. Then more binding compacts are made—some providing a penalty for the cutting of agreed prices; some providing for a division of territory in which sales can be made by competing establishments; some providing for the distribution of the total sales of a product in certain percentages between different establishments. All such compacts are combinations in a greater or less degree of different establishments, any of which may be owned by an individual, a firm, or a corporation, and, with indefiniteness of meaning, have variously been designated as trusts.

They are, however, but the embryo of the trust properly so called, which is a complete amalgamation of different interests in the same industry. Stock is issued covering an appraised valuation of the several properties to be combined, and distributed in proportion to the owners of these properties, who surrender it to trustees, receiving in return therefor trust certificates issued by these trustees, who become the actual directors of the organization. By such a combination competition between its constituent members is removed. The concentration of management permits economy of administration, the organization, as a whole, obtaining the benefit of appliances and methods that before were peculiar to but one or a few of its constituent elements. The interests of the various producers are placed as a trust in the hands of the men whose mental grasp, practical knowledge, and executive ability enable them to direct to most efficient results the efforts of a great number of workers, to adopt and use to greatest advantage the best appliances, to obtain large quantities of the requisite material upon the most favorable terms, to perceive and meet the conditions of a varying market. And thus it is that the formation of a trust is a uniting of the conditions that permit the attainment in the highest degree of the advantages gained in smaller degree by the first industrial differentiation which marked the beginning

of that diversification which is an accepted sign of progress. The trust succeeds the corporation as the corporation succeeds the firm, as the firm succeeds the individual artisan, as the individual artisan differentiated from the Jack-of-all-trades of the early household.

A trust may be a combination of plants and operations theretofore separately conducted by corporations, corporations and firms, or by corporations, firms, and individuals. Its essential characteristic is the solidification of formerly diverse and opposing interests. This may be obtained by a combination under the trust certificate plan, or by the complete absorption of the ownership of the combining elements. Thus a corporation may be absorbed in a trust which may be transformed into a corporation, which in time may form a constituent element of a greater trust. Under each combination there is increased centralization of control and the extension of the operations in a widening field. And it sometimes happens that one man, or a few men closely associated, hold a controlling interest in, or predominate in the direction of, several organizations. There are two or three firms in New York, for example, any one of which regulates the management of two or more railroad or other corporations.

In each sphere of development, from the growth of the planetary systems out of the nebulous mass to the ascent of the living organisms of highest endowment from the protoplasmic mass of dull and homogeneous sensation, all progress has been along the lines of differentiation of function and structure and co-ordination of like functions in a decreasing number of structures or organizations, each characterized by an increasing centralization of control of a broadening field. If the working of the industrial forces that has led to the formation of corporations and trusts is directly analogous to the working of forces that along other lines has led to analogous effects, this industrial aggregation is a natural and inevitable step of industrial evolution that therefore can not but be beneficent in its final results.

As evolution along any line is most direct when its forces are least impeded, the industrial development of the United States should have been most rapid, for here conditions have been more favorable to industrial activity than among any other people at any time in history. The American settlers were of vigorous ancestry; natural wealth abounds; the climate is temperate; and there has been the least retardation from the evils of government, the evils of war, and religious intolerance. From this is another proof that the formation of trusts is a natural step of industrial evolution, for it is in the United States that they have been of most direct growth and have attained their greatest dimensions and their greatest strength.

It has been remarked, with some show of facetiousness, that from the trust that supplies the cradle wherein he is rocked in infancy to the trust that furnishes the coffin wherein he is laid for the tomb, man is housed, fed, clothed, transported, and entertained by a trust of one description or another. And, notwithstanding arraignment in public print and public speech, trusts thrive and prosper. This alone might lead to the inference that they are the product of natural forces.

But trusts are not in possession of the entire industrial field. Not in any one line of industry is the entire production effected by the agency of any one combination. There are even corporations, firms, and individuals engaged in the production, refining, and distribution of oil that owe no allegiance to the Standard Oil Company. There are refiners independent of the sugar trust, and iron manufacturers that are not in any pool. There are trusts in the same line of industry working in direct competition with each other, and also with firms and individuals engaged in like production. For example, the New York Biscuit Company, the United States Baking Company, and a similar company operating principally west of the Mississippi River, are three different trusts engaged in the manufacture of products of the bakery, operating principally each in territory separate from the other; but at points in the territory of either it is in direct competition with the other, and each, in its own territory, is in competition with firms and individuals supplying bread, biscuits, crackers, and kindred articles of consumption. There are towns and villages not reached by any of these trusts that are supplied by local bakers, and there are thousands of households throughout the land producing almost entirely within their own kitchens all the products of grain consumed by their members. A certain similarity to this condition is presented in each other line of industry throughout the entire field. Combination is most marked in industries requiring expensive plants and appliances and the services of a large number of especially trained workers in preparing a product for which there is great and constant demand, the railways and iron and steel and the textile industries all affording conspicuous examples of strong combination. In the more densely populated portions of the country there is combination to a greater or less extent in other industries that, in more recently settled portions of the country, are administered by smaller organizations, the three baking companies being notable examples. A variety of causes, more or less general, more or less particular, have affected combination in the different lines of industry at different places. The general tendency, however, is toward the formation of separate organizations for the manufacture of an increasing variety of specialized products, and toward the combination of the com-

paratively similar organizations concerned in the manufacture of each particular product into a decreasing number of organizations characterized by increased centralization of control and the extension of their operations in a widening field. This tendency is in exact accord with the law of evolution as defined by Herbert Spencer, and the heterogeneous aspect presented by the different coexistent degrees of combination in the industrial field analogous to the heterogeneous aspect presented by the various coexistent stages of development in each sphere of evolution throughout the universe, all phenomena of which are now believed by the deepest thinkers to proceed in accordance with that law.

It is true, however, that in the processes of this industrial development are phases affecting adversely the fortunes of classes and individuals, although working to the benefit of the community as a whole, and there have been phases entailing actual oppression without other attendant good than the bestowal of experience.

The displacement of human labor by machinery and improved economical methods has been the cause of much outcry from those whose earnings have been immediately affected; but that readjustment to meet the advanced conditions can not but be beneficial to society as a whole perhaps needs at this time no extended defense, and likewise with the displacement of labor caused by the cessation of industries at particular places under stress of competition of more favored localities.

In the first reaction from the unremunerative prices forced by competition, a combination sufficiently powerful to do so often raises prices of a product to a point as unreasonably high as previous prices were unreasonably low, and this is the basis for one of the apparently potent arguments against the toleration of trusts—that they are oppressive to consumers. But there is the reply, first, that the desire to obtain the increased profits consequent upon an extending sale of the products will cause the most enlightened managers to keep their selling prices at the lowest point that consistent with profitable production will to the greatest extent increase consumption. When, however, this consideration does not prevail, there is a further check upon the maintenance of exorbitant prices in that capital, which tends to flow into the field in which greatest profits can be made, reduces prices by engendering new competition. Delay in the action of this corrective frequently has been caused by the fact that the making of enormous profits for a time is kept secret oftentimes by a combination engaged in an industry requiring a plant for its operations so extensive that great capital and experienced managers are necessary to establish successful competition; and the de-

lay has been longest when, along with these conditions, the product has been of such a nature that the payment therefor ultimately comes from those not concerned in its immediate purchase. But it is a fact that in the industrial history of the last quarter century, notwithstanding these obstacles, many a combination strongly fortified in the maintenance of undue profit has, sooner or later, had its power broken by the flow of new capital into its field.

In the manufacture of steel beams and steel rails are required plants of great value, and the services of experienced managers and skilled workmen. The charge for beams falls upon the renters of apartments in buildings of the construction of which the beams are part, and the charge for rails upon the travelers and shippers over the railways; and, as the immediate purchasers of the greatest quantities of beams and rails are often, if not generally, not the direct owners of the property for which the purchases are made, and therefore neither the immediate nor the remote payment comes from the pockets of the immediate purchaser, the action of competition in effecting a reduction in the prices of such material has been subjected to extreme delay, but that it finally effects such a reduction is shown by the fact that whereas seven or eight years ago the beam combination was composed of but five establishments who obtained over three cents a pound for their product, there are now over a dozen establishments engaged in this manufacture, and the price obtained is about one and a half cent per pound, and likewise combination after combination of steel rail producers that have endeavored to maintain unreasonably high prices has been broken.

Another corrective of the maintenance of inordinately high prices lies in the fact that a combination making one product upon an extensive scale is prone to discover means whereby waste, incident to that production, which could not be utilized by the smaller producer, can be made a valuable article of commerce, and the combination, therefore, has found it to its interest to stimulate the consumption of its principal product by reducing prices, in order that it may obtain the additional profit consequent upon the increased production and sale of the subsidiary product. For example, when a dressed-beef concern of Chicago found that oleo oil could be made from the inside fat of cattle, it reduced the price of beef to a narrow margin of profit, that it might increase the sale thereof and thereby obtain the increased supply of fat for the production of oleo oil, for which there is great demand. Other dressed-beef producers were forced to reduce the prices of meat accordingly, the result being of great benefit to the consumers of meat, who are practically the entire population.

It has also happened that the maintenance of inordinately high

prices for a particular product has led to the discovery of means whereby another product can be used in its stead, whereby the manufacturers of the original product have been compelled either to reduce their prices or retire from the field.

Competition, before reaching the point where the leaders in a particular industry are forced into final combination, tends to lower the wages of laborers in that industry; for, as it is to the interest of the consumer to procure that which he needs at the lowest cost, his efforts to buy cheaper tend to force the cost of production to the lowest notch. When this pressure for low prices is such that it can not be met by the saving in production gained by the use of economical methods and improved appliances, attack is necessarily made upon the wages of the workmen. Likewise the efforts of the salesmen of a particular product to extend its market in competition with other producers, force the lowest cost of production with like results upon the wages of the workingman. After competition has forced the final combination, the wages of workingmen in but few instances have voluntarily been increased, and sometimes they have been reduced. Those in control of the capital, desiring to recoup for past losses and to secure the greatest returns for the future, still find it to their interest to keep down the cost of production. From this has arisen the cry that a main purpose of industrial aggregation is to crush the workingmen. To retain their employees, however, even great combinations are usually obliged to pay wages not less than can be obtained in other fields. Such combinations must be managed by men of the first ability, whose services can not be secured except for high remuneration. To the efficiency of their work is necessary the careful training of a corps of subordinates to whom it is to the interest of the corporation to give adequate remuneration and certain tenure of position so long as they remain competent. And even to laborers of the lowest grades these corporations must pay a rate of wages established by supply and demand. It is shown by statistics that the rate of wages during the past fifty years has steadily increased, in all except the vocations that are being supplanted and are dying out. The rate of wages is a matter, however, in which self-interest on either side is the principal factor, and, whether forced by competition or actuated entirely by selfishness, employers, as a rule, have not at any time extended any greater compensation to their employees than they have been obliged to. But in opposition to the tendency to force wages down there have also grown combinations, the labor organizations. These are trusts, in that the laborers in a certain field of industry place the care of their collective interests as a trust in the hands of the officers thereof. The theoretical justification for the existence of labor organizations is, therefore, the same as the

theoretical justification for the existence of our democratic form of government—that is, that the best interests of the constituent individuals are best served by placing in the hands of their chosen representatives certain functions which can be better performed for the individuals by those representatives than they could be performed by the individuals for themselves.

When an employer announces a rate of wages, an employee has the right to work at that rate or not, as he may choose—that is, he has the right to contract for his services. But if the manager of a mill, a mine, a factory, or other large establishment employing a great number of workmen engaged in the same kind of work, announces a reduction from the established rate of wages, what is the effect upon the individual workman if entirely dependent upon his individual resources in the negotiations incident to this individual contract? He may continue to work at the reduced wages or not, as he may choose, but to seek work at another establishment is often impracticable, especially if necessitating removal to another locality. To remain without work, even for a short time, entails ill-borne loss. The result is that a portion of the employees may leave, but the majority find it preferable to accept the reduction, especially those who have acquired homes in the vicinity, and live wrapped in the web of attachment woven by the associations of the home, the neighborhood, and the community. The contract for a rate of wages between the employer and the individual is, therefore, one in the negotiations for which the employer has an advantage so tremendous that his decision is practically the mandate of a despot, and, as upon the rate of wages practically depends the employee's subsistence, the amount of necessaries, comforts, and luxuries he can procure for himself and family, the employer oftentimes has greater power over the manner of life and the happiness of his employees than the Constitution accords to Congress and the President of the United States. When this power is used to reduce wages, workingmen have frequently but little means of knowing whether the reduction is forced by the conditions of production and distribution, or whether it is an arbitrary attempt to swell the employer's profits. The conditions of their lives are such that they can not know much of the cost of plants, appliances, material, and the relation that wages bear to the cost of production or to the expense of distribution. In any event, the strong promptings of immediate self-interest impel them not only to resist any reduction, but to endeavor to obtain, from time to time, an increase of wages, a general betterment of condition; and as individual assertion is of little or no avail in resisting reduction or obtaining an increase, the natural result is that the workingmen in a particular line of industry endeavor to obtain by combined action that which they

can not obtain separately, and thus have arisen organizations of the workingmen in different lines of industry, and as they have increased in number and complexity, they have tended toward more extensive combination, with greater centralization of control—witness the Knights of Labor, the Sovereigns of Industry, and the American Federation of Labor. But as the representatives of the people, charged with the administration of the political government, have, times without number, because of ignorance of the working of economic law, because of cowardice in following their convictions, because of personal greed, because of a truckling to popular prejudice, enacted laws, sanctioned executive action, or indulged executive neglect, that have inured to the injury of the people as a whole, so also have the representatives of workingmen, charged with the administration of labor organizations, from like causes, enacted regulations, permitted action, or neglected to restrain action, that has worked to the direct injury of their constituents, and tended to bring labor organizations, as a class, into widespread obloquy. As the demagogue has often obtained political preferment, so also have the palavering hypocrite and the sordid bully but too frequently been made the representative and spokesman of labor; and then, again, it has often happened that well-meaning representatives of labor, after conferences with employers in which they have been clearly shown the conditions that necessitate reduction of wages, or that render impossible an increase of wages, have been repudiated and condemned by their constituents when endeavoring to make such conditions clear to them. All too often have workingmen of the best intentions been overruled by the headstrong, who have worked upon their credulity and prejudice until they have met appeals to reason with unreasoning sullenness, and when minds credulous and prejudiced have been inflamed by liquor there have been deplorable and disastrous results. In years past the conferences between the representatives of capital and the representatives of labor have too often been marked on both sides by aggressiveness, rapacity, and greed, by the absence of good faith and calm, considerate, thorough discussion. Strikes have inured to the injury of both capital and labor, but as strike after strike is fought and ended the reasons for the conflicts come more clearly to the light of publicity, and popular opinion, the basis of all law, seizing upon the points of dispute and perceiving the attitude of the combatants, visits with condemnation or approval the one side or the other; and this light of publicity, searching out that which is unjust in the action of labor and that which is unjust in the action of capital, can not but bring, and may now be seen to be bringing, a healthier tone to the proceeding of one and a greater honesty of consideration to the attitude of the

other, from which can not but come a more reasonable and equitable solution of the problems that are continually presented to each.

And notwithstanding all the attacks that have been made upon them, labor organizations survive. Like the other trusts, they are the product of natural forces; like the other trusts, they fulfill a natural function. As men of greater knowledge and broader views come to their control, the directors of great industrial organizations who want to be just toward their employees find it advantageous to communicate with them through such representatives. The situation can be gone over with them more frankly and thoroughly and in shorter time than would be possible with each of the workingmen separately, or with all of them jointly, and the report and recommendations of these representatives to the workingmen can be met and received as the result of the best judgment of competent minds acting in their behalf. It is to be hoped that in time the perception of a common interest and a common sense of justice between employer and employee will render the labor organizations unnecessary. It is likewise to be hoped that advancing civilization will reach a plane whereon all political government will be unnecessary.

An assertion that has been used with great vehemence against industrial aggregations is that they are instruments for ensnaring and misappropriating the funds of the weak and unwary. Condemnation on this ground was made of the minor industrial and financial combinations. The cry against corporations a generation ago was as bitter as that against the trusts of the present. It has arisen from the fact that the multiplicity of means that have been developed for borrowing capital, the giving of mortgages, the issue of stock certificates and bonds of different kinds and forms, with the attendant manipulation in stock markets, has given men with predominating desire for personal gain opportunity for obtaining money in excess of the needs of their business, or of the value of the property which they can offer as security, and complicated methods of bookkeeping have concealed its unjustifiable application and the misuse of profits. Instances of such defection have been so numerous as to breed in the minds of a considerable portion of the population a certain distrust of all that pertains to the buying and selling of stocks and bonds, and this distrust in many places with many people is so deeply rooted that the advantages to the entire community gained by honestly and discreetly managed industrial combinations are overlooked. It is the men of largest brains and keenest wit that in the fields of finance and industry conceive and control enterprises of magnitude, and when this keenness of wit has been combined with lack of scruple they have often been able to envelop the conduct of their enterprises

in a mystery that the ordinary mind did not penetrate, under the cloud of which they have wrested undue personal gain. The conversion by men to their personal ownership of funds and estates held by them as trustees was an abuse from which the common law for centuries was inadequate to afford immunity. The development of the ethical trust relation sustained by those in active conduct of the great industrial organizations of this century to those whose funds are invested therein has been more rapid than the development of the legal safeguards for the protection of that relation. But as every abuse is the forerunner and the cause of its own remedy, the deleterious manipulation of stocks, bonds, and securities of every sort must give way before a public intelligence that tends more and more to a perception of the methods by which it has been possible. And this intelligence will compel the embodiment in legal codes of measures that will place these recently developed trusteeships upon as clearly defined and safe a basis as the earlier and simpler trusteeships were placed by the system of jurisprudence and jurisdiction organized by the Earl of Nottingham.

It is frequently asserted that a nation's industries are in most healthful condition when conducted by a great number of independent producers. If carried to its logical conclusion, this implies that the village artisan who employs one man to assist him is guilty of an act of injustice. For otherwise, if A has a right to better his condition by working for wages under the direction of B, why should not both A and B, if they can better their condition by doing so, work for wages under the direction of C? And why should not scores and hundreds of men work under the direction of the master mind of Z? It is true that whether impelled by the desire to obtain increased profits, or by the constant demand for the reduction of prices, it is the tendency of an industrial combination to absorb the performance of the functions contributing to the manufacture of its ultimate product, thereby either destroying or curtailing the profits of those theretofore engaged in the performance of those functions. For example, but a few years ago the placing in the Northwestern markets of coal from the Pittsburg bituminous coal field involved the making of profits by the mine producing coal, the agent in Pittsburg that purchased it on commission, the firm who employed him, the company over whose docks it was loaded in vessels at the ports of Lake Erie, the owners of the vessels which carried it to the Northwest, the owners of the docks on which it was unloaded at the head of the lakes, and the dealers who disposed of it in the various Northwestern cities. The pressure of competition reducing the possibility of separate profits has forced the combination of these different agencies of production and distribution—for in-

stance, one man now controls what is practically one organization, owning mines at Pittsburg, docks on Lake Erie, vessels that ply on the lakes, docks at the head of the lakes, and coal yards at St. Paul and Minneapolis. As the retail price for Pittsburg bituminous coal at St. Paul and Minneapolis has been materially reduced in the past ten years, it will be observed that the co-ordination of the various functions enumerated has resulted in immense benefit to the consumers of coal, that has extended throughout the Northwestern States. When contributory functions are absorbed by a combination, the men engaged in the performance of those functions are not deprived of a livelihood. Their services are needed in the performance of those same functions by the combination, which must yield them compensation in accordance with their experience and ability. If it be the effect of this competition to force a lesser income than accrued from the profits theretofore enjoyed, the result, while it may to a greater or less extent be to the misfortune of the absorbed individuals, is for the good of the community as a whole. If the functions which they did perform can be performed by the combination equally well at less expense, it would be unjust to the consumers of the ultimate product for these individuals to continue to enjoy such profits. There is the further consideration that in the performance of the various functions necessary to the continuation of a great organization men of various kinds of ability can devote their energies to the tasks for which they are best adapted. The organization and the nation as a whole are therefore benefited by having the best outcome of men who, if working independently in a smaller sphere, would be hampered by having to give a greater or less proportion of their time to tasks for which they are less adapted.

The instinct of self-preservation, carried to its extreme in the desire for the greatest gain with the least liability for aggression, is apparent in the different steps of industrial combination. The limited partnership laws in effect in many of the States contain provisions restricting liability that, as a rule, have stood the test of application, but there has been much irregularity on the part of corporations that, obtaining a charter under the laws of a particular State, have gained advantages that have permitted operations in other States under the laws of which similar privileges could not have been obtained; and, conversely, particular States have placed unjust restrictions upon the operation within their jurisdiction of corporations working under charters obtained in other States. The desire to evade responsibility, together with the desire to evade the assault that in many localities is facilitated by the laws arising from distrust of corporate action, has led certain of the combinations known as trusts to adopt carefully

studied and elaborate plans of organization that permit the greatest freedom of operation, while reducing to a minimum the opportunity for legal attack. Such devices, to the extent that they exceed the bounds required for proper self-protection, can not long stand before an increasing intelligence of their aims and methods. That same intelligence, acting through the media of courts and legislatures, must arrive at a more equitable solution of the problem of corporate rights and corporate aggression.

In the effort to extend to the greatest degree the sale of its products, a trust now and then has adopted other measures than the endeavor to place upon the market products of a quality and price that will insure the largest consumption. In certain localities it has, regardless of immediate loss, placed the selling prices of its product at a point so low that a competitor can not meet them without loss that, if continued, will drive him from the field. But it has happened that the resources of a competitor, or his facilities for production, have been such that he can successfully defy such an onslaught. In such a case a trust has sometimes adopted another method of attack by coercing merchants into desisting from the sale of the competitor's products under threat of using the influence of the trust to harass and embarrass them. Such methods, although sometimes apparently successful, often redound to the injury of the user, for one of the first steps of the object of the persecution is to enlist sympathy by giving publicity to his position. When, however, an industrial organization gives a merchant who agrees to sell its products to the exclusion of similar products of other manufacturers lower prices than if he also handled competitors' goods, it is simply acting upon the established principle of selling greater quantities at lower prices than lesser quantities. If these low prices yield a profit to the producer, and the products can be sold by the merchants at a lower price than similar products of competing producers, the result is that consumers are benefited by the reduced prices, and the profits of the merchants and manufacturers are increased by reason of the extended consumption.

An organization controlling the shipment of large quantities of material used in manufacture, or of a finished product, has oftentimes been able to obtain lower rates of transportation than its competitors because transportation companies have underbid each other in the desire to obtain the extensive traffic, and the advantage gained by means of the low rates has contributed to the exclusion of competition. Many of the States have established commissions to look into the administration of transportation companies, and the Interstate Commerce Act was the beginning of national action in the same field. And the State and national commissions are throwing light on the problems of trans-

portation that have been but little understood. Abuses are being corrected, and in many instances procedure supposed to be to the injury of the public in general is shown to flow from the action of natural forces tending to the public good.

Much that has been evil in the conduct of trusts has been ascribed to the working of our so-called protective tariff, and the exclusion of foreign competition has, doubtless, been an important factor in the over-capitalization of different plants and the watering of stock that have been almost constant elements in trust formation. But it is not to be inferred that an abandonment of or a reduction in the tariff would be followed by the dissolution of trusts. If the greatest economy of production is obtained under a trust, which is the final combination forced by competition, will not the renewed and intensified competition consequent upon an abandonment of or a reduction in the tariff render the trust all the more necessary? The foreign competition will doubtless hasten a reduction of undue profits, but at the same time will tend to increase the compactness of organization and method under which the final industrial combination is of greatest good to the community. The three baking companies referred to on a preceding page are examples of trusts the formation and continuance of which do not depend upon any advantages derived from the tariff. The United States Baking Company was formed under the pressure of competition entirely domestic. It thrives because the operations of the constituent baking establishments are conducted under centralized control, by which is obtained for each the advantages of the best appliances and methods, the best adapted material at the lowest cost, and the most judicious distribution of the products.

As it often happens that the actions of a servant, performing his duties quietly and efficiently to the increasing satisfaction of his master, meet with no other recognition than the stipulated compensation, although departure from the exact line of correct performance, whether apparent or actual, whether the result of ignorance, carelessness, or positive dishonesty, meets with complaint, rebuke, and punishment, so it has happened that an industrial combination which is but the servant of the public, so long as its operations have been confined to the production and marketing of articles for which there is a demand, of a quality and at prices that satisfy that demand, has been permitted to continue its functions without particular attention, receiving reward in the profits accruing from the sale of its product. But the real or apparent departure of such an organization from the simple performance of such functions, whether the result of actual aggression or the disturbance entailed by the readjustment to changing conditions, brings outcry that has been followed by that public

rebuke which has ended in legislative enactment designed to prevent a continuance of the real or apparent abuse. The discharge of employees, the reduction of wages, the raising of prices, the decrease of production, whether justifiable or not, antagonize the immediate interests of a greater or less proportion of the population whose discontent often finds voice through men who, whether sincere or guided by self-interest in their protestations, are utterly unable to trace the ramifications of cause and effect throughout the complications of the industrial and commercial web. And such men, clothed with the power of legal enactment, have given force to statutes that have tended to kill instead of to cure. But it can not be denied that the desire for gain, without due regard for justice, has led men charged with the administration of industrial organizations into actions that have abundantly justified public complaint and severe punishment, and many organizations have been formed because of the facility for public aggression attained by combined action and the absence of individual responsibility; and all that has been reprehensible in the acts of such organizations, gaining a greater or less publicity, has tended to obscure the perception of the benefits of industrial combination as a whole.

The enumeration of the evils attendant upon combined action leads to the perception that they did not spring into existence at any one period of industrial development, but that they are the outgrowth of not properly restrained actions, arising from motives that exist in individuals, and were manifested in the actions of individuals before the tendency toward combination became noticeable, and have been manifested with increasing conspicuity at each of the stages of combination. In other words, the vices and virtues of aggregations of men are but the vices and virtues of individual men, and vice and virtue alike become intensified as they are manifested in the actions of an aggregation of men controlled by leaders of whom they are characteristic. Opportunity for dispute as to the rate of wages and the hours of labor arose when there were first employer and employee. It is the very trading instinct to sell at the highest price and purchase at the lowest. The mean and the crafty have ever sought to obtain money without repaying it, to obtain privilege without compensation, to gain advantage over others by fair means or foul. As it has been the increase of intelligence and morality and accumulated experience that has led to a wider justice between individual men, so must it be the increase of intelligence, morality, and accumulated experience that will lead to the allotment of justice between individual man and an aggregation of men, and between aggregation and aggregation.

The very hugeness of the more recent industrial combinations

has raised in the minds of many a vague fear akin to that which children feel when they read of giants and genii, and politicians have conjured with their names as nurses frighten infants with tales of great monsters that are coming to eat them, and this notwithstanding that the greatest effect in all fields of human effort has been gained through organizations, characterized by combination and recombination, that, working under centralized control, have enlisted great numbers of men in the attainment of far-reaching ends. The advantages of combined action in bodily attack and defense led step by step through the grouping of tribes and clans to the formation of great armies. Upholders of like ecclesiastical doctrines have associated themselves in organizations that have sought to extend their sway by united effort. Similar needs of similarly conditioned masses of men have caused the growth of political governments that have combined and recombined. With advancing civilization the soldier's calling becomes of less and less importance; with the growth of the intellect ecclesiasticism loses its dominance; and with the loosening of the shackles of paternalism the sphere of political government recedes. Advancing humanity now demands, more than ever before, the service of him who contributes most to that wholesome care of the physical being which is essential to the highest development of the mental and moral life. The artisan and the tradesman, who were the butt of ridicule, the object of contumely, when my lords the warriors and my lords the bishops ruled the world, find that their vocations, increased and extended by the aid of science, are of inestimable value to the human race. The forces tending toward the highest civilization, that through physical conflict have evolved the great nations which abide side by side under a fuller promise of peace—that throughout the strife between mind and mind as to the Unknown Cause have evolved the great religious organizations that seem more and more content to abandon useless dogmas, to join in the promulgation of moral precepts that are common to them all and in the ever more discreet ministration of charity—are now swirling with greatest intensity in the field of industry, evolving the great industrial organizations, that through the mutual reaction of one upon the other will bring that clearer knowledge by means of which they will be made the peaceful and harmonious agents of the higher life. And therefore, inseparable from consideration of the causes that have led to industrial combination and the effect of industrial organizations in the present, is speculation as to the direction the tendency toward such combination will take in the future, the extent to which it will involve industrial functions, and the effect the organizations will have upon the individual life of the members of a community.

Functions, the performance of which particularly depends upon the skill and application of individuals and have little connection with concrete production, will likely to a considerable extent remain exempt from combination, although attorneys and physicians whose pursuits depend almost exclusively upon separate individual ability and application have allied themselves in associations through which to an extent fees are regulated and the experience of individuals is brought to the benefit of all. A striking example of the centralization tendency is presented by the action of the banks in many of the larger cities during the recent financial distress. To the clearing house, which is primarily but a combination of banks for mutual benefit, which inures also to the benefit of the public, were assigned securities belonging to each of the banks holding membership therein, to be held by the clearing house as the basis for the issue of clearing-house certificates which were designed for the benefit both of the banks and of the community served by them. As the property of the different banks was placed in the hands of a committee clothed with executive authority, this action displayed a principal characteristic of the trust formation.

Consideration of the effect of industrial organizations upon the individual lives of their members leads to analogy drawn from the relation borne by the individuals thereof to the other great organizations that have attended the progress of humanity. As the true soldiers were content to find their reward and glory in the valorous service of the militant organizations to which they belonged, as the sincere ministers attained the highest personal good by the abandonment of self in the striving to uphold the precepts of their creeds, so it may be that the members of a great industrial army, imbued with the feeling that their well-directed energies contribute in the greatest possible degree to the welfare of the nation, to all that is meant by the attainment of the highest civilization, will find happiness in their work that is only equaled by the happiness found in their homes, and will be content with the personal credit and personal reward that may follow the exercise of their ability in a field where an increasingly juster perception of each man's capacity will give the opportunity for its fullest utilization, and where there is increasing recognition of the fact that it is to the efforts of all the workers in a particular field that results are due, that the credit in proportion to his usefulness belongs to the private as well as to the general. The manager of a great railway gives the best of his mental and physical energy to the conduct of its affairs, with the consciousness that he is thereby contributing to the welfare not only of the corporation and its employees but of the community which it serves; likewise with the president of a bank or the head of a great industrial or-

ganization. The name of the organization he serves may have endured for long before his term of service and for long after, as the name of the nation endures throughout many changes in the head of its government. If a prime minister finds more than pecuniary reward in having risen to the most important place of service to his nation, so should a captain of industry find more than pecuniary reward in having risen to the place of most important service to a great industry that ministers to the welfare of a multitude of people. If a sailor in the navy takes pride in contributing his mite under his nation's flag, so should the industrial private find satisfaction in the thought that his efforts are of use.

Besides the pleasure that he should find in his work, there is the happiness man should find in his home, in wholesome recreation, and the development of his mental and moral nature. That which is essential in the enjoyment of home does not depend upon the place in the industrial world occupied by the head of the family, for that there may be contentment in the cottage and misery in the palace is proverbial. Now that wise managers are discovering that the best work is obtained from men whose life in its entirety is most wholesome, it may be expected that in time the executive heads of great organizations will endeavor to allow their fellow-workmen every reasonable facility for domestic enjoyment, healthful recreation, and self-culture. And all the advantages gained by industrial combinations lead to this end. As products are cheapened their use becomes extended, so that in time it may be expected that the humblest may possess themselves of the clothing, food, and conveniences of habitation that minister in greatest degree to bodily health. As men working in concert with improved appliances and under improved methods produce a greater and greater output in less time and with less nervous and muscular exhaustion, it may be expected that before many generations have passed the labor necessary to supply the material needs of the human race may be encompassed within limits of time and exertion that will allow to all sufficient leisure and sufficient spirit for the cultivation of all that gives to life its perfect flower. The great industrial organizations perform for all the people what the men and women in the days of our grandfathers did for themselves and their families. They extend the mutual helpfulness of all the members of the nation, binding community to community, "obtaining an advantage while conferring a boon"; and the increasing exchange of products between nation and nation gives reason for belief that in generations to come, as the individuals of different nations know and appreciate one another more truly, there may be an extension of industrial organization that will have the whole world for its scope, ministering to all mankind.

A recapitulation and summary of cause and effect throughout the industrial development of the United States as outlined in the foregoing pages lead to the conclusions:

That specialization of function and co-ordination of similar functions become more pronounced with the growth of population and ease of communication; that this specialization and co-ordination is accelerated by the invention of machinery, the discovery of processes whereby the production and distribution of greater quantities of an increased variety of products are facilitated; that this specialization and combination are of benefit to all individuals of the nation in that they bring to the control of the processes of production and distribution the men best fitted therefor, under whose directions the efforts of great bodies of workers are co-ordinated to the greatest advantage, and under whose direction the accumulations of great numbers of people can be used with profit to the investors and to the individuals of the whole nation, for this specialization and co-ordination lead to the production and distribution on an ever-extending scale and at decreasing expense of the products that contribute to the strength and fitness of the buildings in which these individuals live and work, in which they congregate for instruction, deliberation, and recreation; of the products that nourish and the products that clothe the body under the varying conditions to which it is subjected, thereby aiding each individual to preserve for the greatest period that condition which permits the effective performance of the functions dependent upon physical action.

That a powerful factor in this industrial specialization and combination and in the diffusion of the benefits thereby attained is the force known as competition. Increased demand causes increased production by an increased number of producers, who, by competition, are forced to lower selling prices and are thereby forced to the discovery, invention, and adoption of appliances and methods that decrease cost of production. Competition, still encroaching upon their profits, incites a combination of producers in self-defense, but to withstand its still active force they are compelled to production only in localities where conditions are most favorable and to vest its control in men most competent to direct it. Competition that rippled and eddied around and among the simpler organizations of employer and employee gains increase of force as the agencies of production combine, and rolls in mighty waves upon a great organization, washing away and crumbling every point of weakness, until there is left but that wall of bed rock formed by production and distribution upon the most economical basis that can be maintained with justice to producer and consumer alike.

That as the conditions incident to industrial combination have

caused a differentiation in the ranks of producers, forming the elements distinguished as capital and labor, the force of competition upon the producers has tended not only to reduce the profits of capital but the wages of labor. As capitalists have combined to protect their profits from the encroachment of competition, so have laborers combined to protect their wages from the encroachment of other laborers, the encroachment of competition acting through the capitalists, and the encroachment of the capitalists direct. And as the action of these labor organizations throughout the industrial field tends to obtain and preserve to the workingman a share of the benefit derived from the sale of products in proportion to the value of the part in the production of which his efforts have contributed, they fulfill an important function in the attainment and maintenance of that equitable relation between the consumer and producer which constitutes industrial equilibrium.

As the argument from every point of view goes to prove that industrial combinations are the products of natural forces ministering eventually to the highest good of the individuals of a community, of the community as a whole, and to community and community in domestic and international relationship alike, lawmakers should have care that in the effort to rid the tree of poisonous growth they do not interfere with the current of the life-giving sap. The object of legal enactment should be the maintenance of justice between man and man, without hampering beneficent activity that will be driven into proper channels by the same forces that give it existence.

SUNSHINE THROUGH THE WOODS.

By BYRON D. HALSTED.

THE title above might suggest a forest that has been shot through by the light of day, or some delightful dell where the rays of the sun make every spot enchanting. Quite otherwise, the lines to follow deal with the printing of pictures of sections of woods by means of the direct sunlight, and some of the points of structure thus brought to view.

If any object through which the light passes unequally in its various parts be brought close against a sensitized paper used by photographers in printing pictures from their negatives, it is evident that an impression will be produced. This print will be a negative, or, in other words, the dark parts in the subject will be light and the light parts dark. For example, the section of papaw wood shown in Fig. 1 is a negative, while in Fig. 2 is the

positive, and corresponds closely with the wood itself in its light and dark parts.

The first essential in getting prints of woods is to obtain uniformly thin sections of the wood. These are not far to seek, for Mr. R. B. Hough has become famous for his wood sections. The

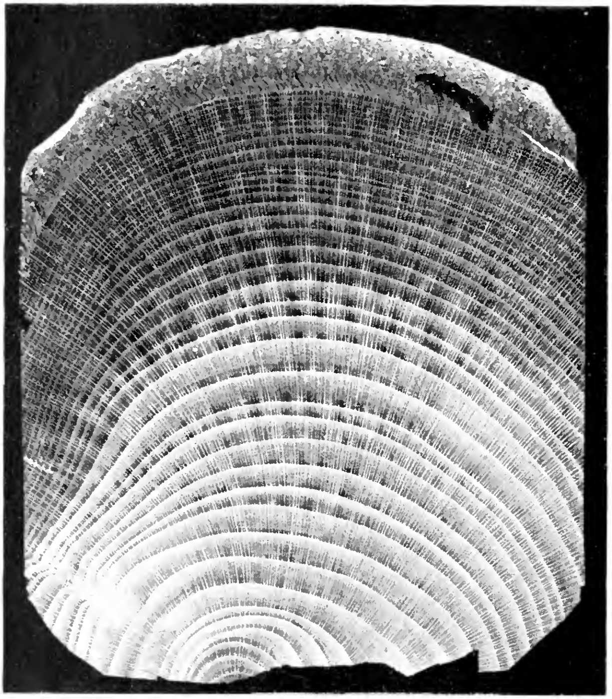

Fig. 1.—Section of Papaw Wood. Negative.

process by which he is able to obtain his beautiful sections is not known to the writer; but to him thanks are due for the specimens which have been used in making the prints to illustrate this paper.

Having glanced at the two mentioned engravings and remembering that very much of the fineness of detail is necessarily lost in the engraving process, the reader is ready to consider the method of making the prints. The sections of wood having been secured, the only other things needful are a few "printing frames" (one will answer) of the ordinary sort used by photographers. Instead of the glass negative which the photographer uses and has prepared in the dark room, a simple plain pane of glass is needed. This is placed in the frame; upon it is put the section of wood, and over the latter a sheet of the sensitized paper. This paper is brought close upon the wood by means of the clamps, and the frame is ready to be placed in the sunlight. After the print is

made, which takes only a few minutes, the time depending upon the strength of the light and the porosity and translucency of the wood, the print is subjected to the toning process, and, after washing and drying, is ready to become the negative from which the final print is made. In order that the light may pass more readily through the negative it is soaked for a few minutes in kerosene and wiped dry upon the surface. The negative is then placed paper side down upon the plain glass in the printing frame, and upon its face is brought the sensitive side of a fresh sheet of paper, the two sheets being pressed close to each other and evenly against the glass by the clamps, as before stated. In a very brief period a positive print is obtained, which upon removal is toned in the usual way, and becomes a picture—the one, for example, furnishing the subject for the engraving in Fig. 2.

What with the brief description of the manner in which solar prints of translucent objects are made, the reader may wish to go

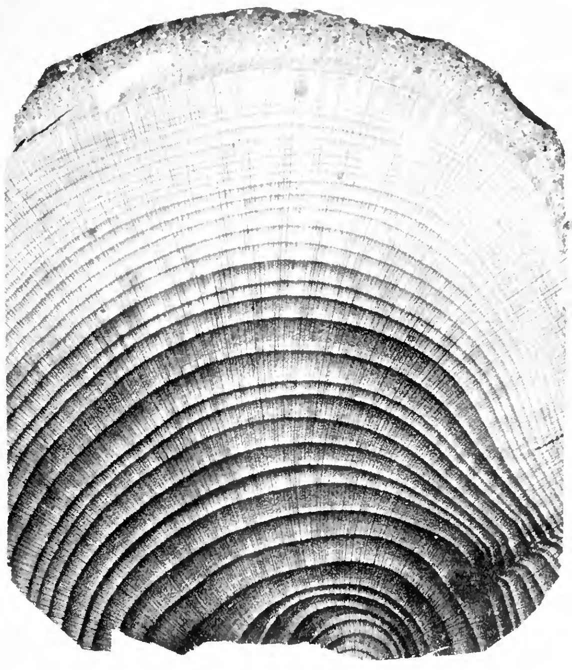

Fig. 2.—Section of Papaw Wood. Positive.

further and consider some of the differences of detail in the various kinds of wood, for one kind of timber differs from another in many ways. Should we, for example, turn to the Report on the Forests of North America, in the last census, no less than four hundred and twelve kinds of timber would be found distributed

through fifty-two natural orders of plants. Sixteen of these are heavier than water, and have a specific gravity varying from 1·3020 in the black ironwood of southern Florida to a white oak (*Quercus grisea*) of New Mexico with the wood only slightly heavier than water—namely, 1·0092 for its specific gravity. It is interesting to note in passing that all these sixteen kinds of wood that will sink in water are natives of southern Florida, a semi-tropical region, and the South and West regions, none of them growing in the Mississippi Valley or east of it.

The black ironwood above mentioned as having the heaviest wood is in many respects a striking contrast with the giant redwood (*Sequoia*) of California, which is not only the largest of our trees, but its wood is among the lightest, it having a specific gravity of only 0·2884, or about one fourth as heavy as the iron-

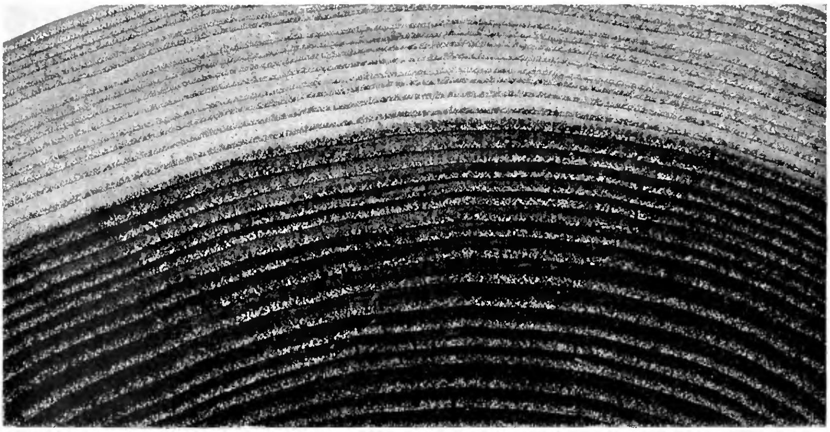

Fig. 3.—Cross Section of Ash Wood.

wood, which latter is a small, gnarly tree of no value as building timber.

It was said that there are four hundred and twelve species of timber receiving treatment in the census report, and therefore it is appropriate to show the peculiarities of the one that stands midway of this long list as regards its specific gravity, and especially so as it is one of the more common sorts and a very valuable timber for many purposes—namely, the ash (*Fraxinus*).

Fig. 3 shows the appearance of this wood as seen looking upon the smooth surface of the end of a stick of timber. It is a decidedly porous wood, as indicated by the minute, light dots which are arranged in a series of curved belts in the engraving.

This leads us naturally to consider somewhat in detail the general make-up of a stem or trunk of a tree. The primary division of the parts is into the wood and the bark. The latter is

shown in Figs. 1 and 2 as a substance quite different from the wood that lies within, and is protected by it. Growth of the stem of ordinary trees takes place in a continuous zone just beneath the bark, the latter being also supplied with new material, as it may be needed to supply the same formative layer. As the years roll on, the wood first made, while the stem was small, and

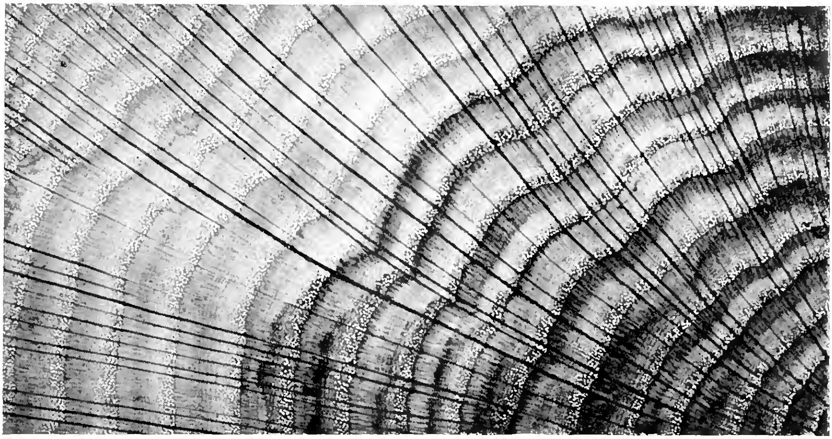

Fig. 4.—Cross Section of Pin Oak. Positive.

now situated near the center, changes its appearance by taking on some color, the shade being determined by the kind of wood. In some of the "precious woods," so called because of their great value for special purposes and possibly their variety, the central or heart wood is nearly jet black, as in the ebony. There is usually a marked difference in the color between the latest formed sapwood lying close under the bark and that formed many years before and now covered by later layers.

We have come now to consider another point of structure previously hinted at and plainly shown in the negravings, namely, the rings of wood. The tree as it enlarges from year to year leaves in its structure the evident record of its life. Each growing season is marked by a ring of wood, and only under the most adverse circumstances is this deposit omitted, and likewise extraordinary events only can lead to the formation of two rings. Therefore with a fair degree of certainty the age of a forest giant can be determined by the number of annual deposits of wood in rings around the common center.

These deposits become manifest to the naked eye, because of the difference in structure between the spring and autumn deposits, speaking of course for tree growth in the temperate regions. Glance at the papaw stem in Fig. 1, and it will be seen that the lower portion includes the heartwood nearly to the cen-

ter of the stem. This is determined by the shortness of the diameter of the lowermost segments. It goes without further saying that the annual rings in exogenous (outside growers) stems vary in age from the youngest upon the outside to the oldest at the center. The point for us to determine is the lack of uniformity in the wood and why that lack is somewhat regular. In other words, the woody tissue of a stem is heterogeneous only within certain limits. Thus in the wood shown in Fig. 1 there are thirty-nine rings, and the tree for our purpose may be considered forty years old in round numbers. Twenty of these rings, or the older half, show a marked color, being much darker than the superimposed twenty years of annual deposits. Several other things are shown by this section, and we can well dwell upon this specimen, as it illustrates facts that are common to nearly all trans-

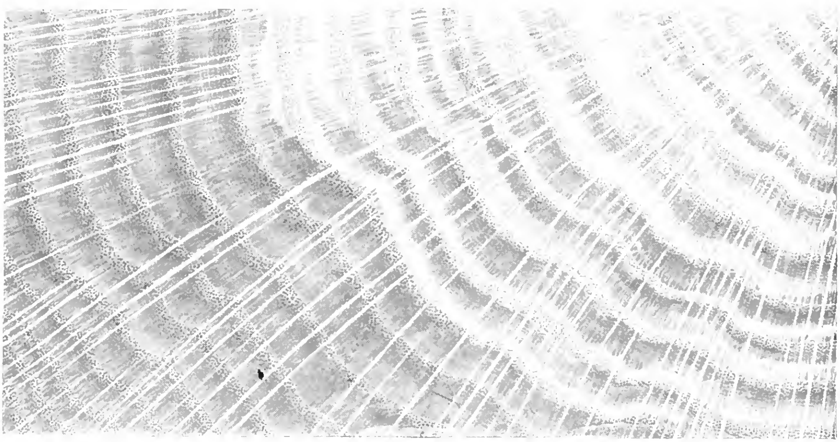

Fig. 5.—Cross Section of Pin Oak. Negative.

verse cuts of wood. The rings, for example, are not all of the same width, those formed while the tree was passing from its fifth to the twentieth season being the largest, but even among these there is a wide variation. Thus, ring fifteen from the center is a narrow one, followed by one of unusual width. For the last ten years the rings have been more uniform and much thinner than twenty years earlier. There may be one or more of many reasons for a ring being unusually thin, as, for example, a short season, one lacking in moisture or having an excess of it, injury from frost, fires, insects, or parasitic fungi. The decrease in thickness toward the outside of the papaw may be due to insufficient nutrition, approaching old age, etc., but in this connection it must not be overlooked that the amount of actual wood deposited may be more in a thin ring at the fortieth year than in a comparatively thick one at the tenth year, the surface covered being so much

more extensive. It is likely that the root and leaf surface may not increase in the same ratio as that of the cambium or growing layer.

Let us now confine our attention to any one ring—the one, for example, near the middle of the engraving. It is bounded upon the inner and outer side by a dark line. Starting at the dark inner line, the ring of wood is very porous, as shown by the multitude of small holes giving a light appearance to this portion of the ring. Farther out the wood in the ring becomes more dense, until it ends in the almost solid outer dark band. This dense layer is in fact the last portion of the annual ring to be formed, and is laid down toward the end of the growing season. The next spring a new ring begins to form just outside this dense layer, and is often produced rapidly and with many large ducts and vessels among the woody fibers. In short, the ring of wood increases in density from the inside to the outside, and this being followed up year after year, the most dense or autumn wood is brought close to that which is the most porous, and the ring structure when seen in mass inevitably results.

It is not unusual for one side of a stem to grow faster than another, and then after a few years the center is toward one side of the middle, and the stem is called excentric. This is quite uniformly the case with all climbing stems, and the writer has a vivid recollection of a microscopic study of this subject of stem eccentricty in the poison ivy, for the work was interrupted by the swelling and closing of the eye most engaged in the task. Fig. 1 is still a fertile subject, and gives the observer a view of both this eccentricity and an irregularity not uncommon in stems. For some reason—and it might have been one of many—when the stem was about ten years old a defect developed, as shown upon the lower right-hand side, when each succeeding ring formed quite an angle that was gradually outgrown during the subsequent ten years. This blemish is shown perhaps to less advantage in the positive (Fig. 2).

The points that have been brought out in the papaw stem are also shown in the section of the ash. From what has been said it is evident that the lower side of the picture represents the inner side of the section. The center of the tree was where two pencils would intersect if held with their tips to the right and left side respectively of the lower edge of the engraving and at right angles to the curvature shown by the rings of growth. The tree from which the section used in the engraving was cut must needs have been at least a foot in diameter, but how much more can not be determined, for there is no means of knowing how far it is from the outermost ring shown to the bark. This could be determined in a general way from a knowledge of the ratio

which obtains between the sapwood and the heartwood in this species.

The ash has certain peculiarities which separate it quickly from the papaw and most other woods. There is, in short, almost as much individuality in the woody tissues as in the foliage or flowers of many trees. Note, for example, the well-marked porous

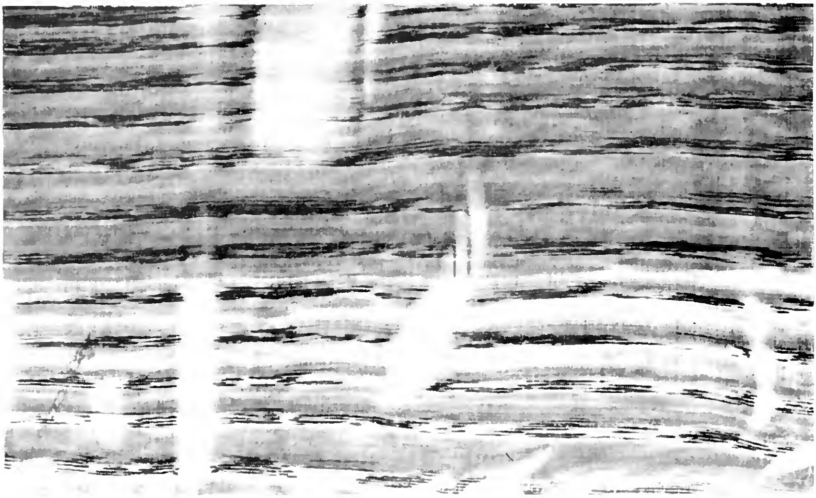

Fig. 6.—Radial Section of Pin Oak.

portions, each ring being made up of two quite distinct parts, namely, the open vascular inner part and the dense fibrous outer portion. This arrangement of substance is conducive to that elasticity so characteristic of the ash, and, together with its medium weight, fits it for very wide and extensive service in implements and other ways.

There is another feature of woods, and one of great value from the artistic as well as economic standpoint, that the solar print illustrates. It is shown in some of its beauty in Figs. 1 and 2, while it fails quite completely in the ash—namely, the thin, radiating bands which connect the center of the ste with the periphery and are known to botanists as the medullary rays, and to the workers in wood as the "silver grain." Fig. 4 is here introduced as showing this element of structure in a remarkable manner. The section is of the pin oak, and the lower right-hand corner represents for our purpose the center of the stem. The rings of wood are wide, irregularly scalloped, and show the points of structure previously mentioned in a superior manner. But best of all are the lines shot through the whole timber like rays of light (in the negative, Fig. 5) from the center to the circumference. They introduce another element, which up to this time has been left

in the background. An exogenous stem may be said to consist of a central pith, seen best during the first years and often thereafter disappearing, and an outer ring of pithlike substance, the inner bark, and a series of plates connecting the two, also of the nature of pith. These thin plates separate incompletely the wood into wedges, and on account of them it often splits more easily in radial lines than in others, and may crack along them in ordinary drying. These thin, shiny, radiating plates of cells lying between the ordinary tissue of the wood give to some sorts of timber its beauty and value. Oak in all its strength would be lacking in much of its peculiar attractiveness were the silver grains absent. Fig. 6 shows a radial, longitudinal section of the pin oak with a few of these plates in view. They are usually small in area and appear in the finished article of furniture as shining, smooth patches, no two of the same size or shape. The beauty of this system of radiating plates is often enhanced by a curling and twisting, due to small knots scattered through the wood, as instanced in some sorts of maple, as the so-called "bird's-eye," a most attractive wood for finishing.

The birch is a good illustration of the wood being flecked, as shown in Fig. 7, a sample of the river birch. This wood is

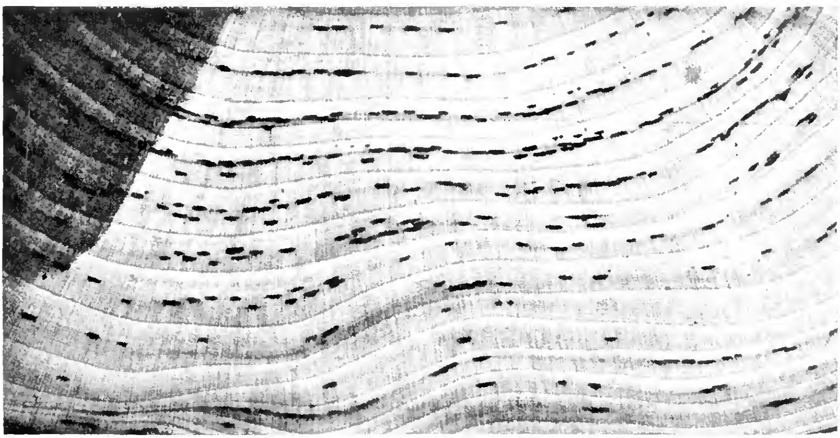

Fig. 7.—Cross Section of River Birch.

peculiar in the absence of any conspicuous medullary rays, and of prominent vascular areas in the annual rings, and therefore with the exception of the pithy patches, the wood is quite uniform throughout; but the coloration characteristics of the heart may appear upon one side of the center like a radiating fan, thus showing that the change of color is far from constant, and does not depend upon the wood having reached a certain fixed age.

Many other sections of wood might be shown, and each in its

turn would exhibit peculiarities, but the purpose of the paper it is hoped has been attained—namely, to show engravings made from sun prints of thin sections of wood with the various elements of structure in the proper position and of natural size.

A single enlarged view of a section of the ash is herewith given, and both indicate the structure seen in Fig. 8 on a larger scale, and show that pictures of such objects may well be taken

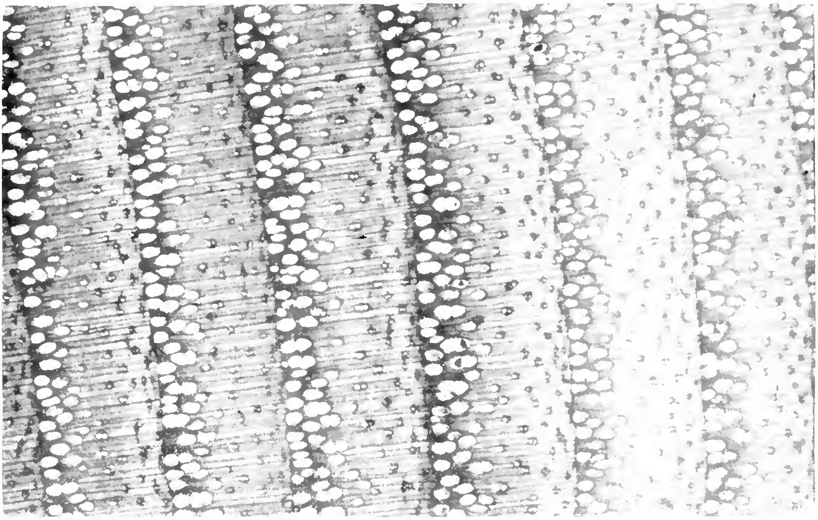

Fig. 8.—Cross Section of Ash. Magnified.

with the light passing through the object falling upon the sensitized plate in the dark chamber of the camera. By a comparison of Figs. 8 and 3 it will be seen that the two show the same ash wood in transverse section. In fact, a small portion of Fig. 3 near its center was selected for the picture from which engraving 8 was made, and this last is therefore no exception, for it was also a catching of a picture by Sunshine through the Wood.

In his subterranean explorations from 1888 to 1893, M. Martel has found that the temperature of natural caves is not equivalent to the mean annual temperature of the place, but is inconstant; is not uniform in different parts of the same cave; and that the temperature of water in caverns is subject to the same variations as the temperature of the air, and is sometimes very different from the temperature of the air. The causes of these variations are not well understood, but as among them M. Martel mentions fissures admitting air from without; cavities in which cold air settles; and the influence of water, which cools the air through the evaporation of its oozings, or, when streams flow through the cave, brings in all the variations of the external air.

STUDIES OF CHILDHOOD.

I.—THE AGE OF IMAGINATION.

By JAMES SULLY, M. A., LL. D.,
GROTE PROFESSOR OF THE PHILOSOPHY OF MIND AND LOGIC AT THE UNIVERSITY COLLEGE, LONDON.

ONE of the few things we seemed to be certain of with respect to child nature was that it is fancy-full. Childhood, we all know, is the age for dreaming, for decking out the as yet unknown world with the gay colors of imagination, for living a life of play or happy make-believe. So that nothing seems more child-like in the "Childhood of the World" than the myth-making impulse, the overflow of fancy to hide the nakedness of things.

Yet even here, perhaps, we have been content with loose generalization in place of careful observation and analysis of facts. For one thing the play of infantile imagination is probably much less uniform than is often supposed. There seem to be matter-of-fact children who can not rise buoyantly to a bright fancy. Mr. Ruskin, of all men, has recently told us that when a child he was incapable of acting a part or telling a tale; that he never knew a child "whose thirst for visible fact was at once so eager and so methodic." * We may accept the report of Mr. Ruskin's memory as proving that he did not idle away his time in day dreams, but by long and close observation of running water and the like laid the foundations of that fine knowledge of the appearances of Nature which everywhere shines through his writings. Yet one may be permitted to doubt whether a writer who shows not only so rich and graceful a style but so truly poetic an invention could have been *in every respect* an unimaginative child.

Perhaps the truth will turn out to be the paradox that most children are at once matter-of-fact observers *and* dreamers, passing from the one to the other as the mood takes them and with a facility which grown people may well envy. My own observations go to show that the prodigal output of fancy, the reveling in myth and story, are often characteristic of a period of childhood only. We are apt to lump together such different levels of experience and capacity under that abstraction "the child." The wee mite of three and a half years, spending more than half its day in trying to realize all manner of pretty, odd, startling fancies about animals, fairies, and the rest, is something vastly unlike the boy of six or seven whose mind is now bent on understanding the make and go of machines and of that big machine the world.

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* Præterita, p. 76.

So far as I can gather from inquiries sent to parents and other observers of children, a large majority of boys and girls alike are for a time fancy-bound. A child that did not want to play and cared nothing for the marvels of story-land would surely be regarded as queer and not just what a child ought to be. Yet supposing that this is the right view, there still remains the question whether imagination always works in the same way in the childish brain. This is a point about which we are beginning to know something definite. The movements of fancy may be expected to have as many directions as the impulsive forces of young interests, and these we know are numberless. Fairies and angels (which are not differentiated in the child's consciousness), the animal world, the mysterious past before the baby came, the doings of the great people up in the sky—these appear to be some of the favorite haunts of the young fancy.

Science is beginning to aid us in understanding the differences of childish imagination. For one thing it is leading us to see that a child's whole imaginative life may be specially colored by the preponderant vividness of certain orders of images; that one child may live imaginatively in a colored world, another in a world of sounds, another rather in a world of movement. It is easy to note in the case of certain children of the more lively and active turn how the supreme interest of story as of play lies in the ample range of movement and bodily activity. Robinson Crusoe is probably for the boyish imagination more than anything else the goer and the doer.*

With this difference in the elementary composition of imagination there are others which turn on temperament, tone of feeling, and preponderant directions of emotion. Imagination is intimately bound up with the life of feeling, and will assume as many directions as this life assumes. Hence the familiar fact that in some children imagination broods by preference on gloomy and terrifying objects, religious and other, whereas in others it selects what is bright and gladsome; that while in some cases it has more of the poetic quality, in others it leans rather to the scientific or the practical type.

Enough has been said perhaps to show that the imaginativeness of children is not a thing to be taken for granted as existing in all in precisely the same way. It is eminently a variable faculty, requiring especial study in the case of each new child.

But, even waiving this fact of variability, it may, I think, be said that we are far from understanding the precise workings of imagination in children. We talk, for example, glibly about

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* The different tendencies of children toward visual, auditory, motor images, etc., are dealt with by P. Queyrat, L'Imagination et ses variétés chez l'enfant.

their play, their make-believe, their illusions; but how much do we really know of their state of mind when they act out a little scene of domestic life or of the battlefield? We have, I know, many fine observations on this head. Careful observers of children and conservers of their own childish experiences, such as Rousseau, Pestalozzi, Jean Paul, Madame Necker, George Sand, have told us much that is valuable; yet I suspect that there must be a much wider and finer investigation of children's action and talk before we can feel quite sure that we have got at their mental whereabouts, and know how they feel when, for example, they pretend to enter the dark wood, the home of the wolf, or to talk with their deities, the fairies.

Perhaps I have said enough to justify my plea for new observations, and for reconsideration, in the light of these, of hasty theories. Nor need we object to a fresh survey of what is perhaps the most delightful side of child life. I often wonder, indeed, when I come across some precious bit of droll infantile acting, or of sweet child-soliloquy, how mothers can bring themselves to lose one drop of the fresh, exhilarating draught which daily wells up from the fount of a child's fantasy.

Nor is it merely for the sake of its inherent charm that children's imagination deserves further study. In the early age of the individual and of the race what we enlightened persons call fancy has a good deal to do with the first crude attempts at understanding things. Child-thought, like primitive folk-thought, is saturated with myth, vigorous Fantasy holding the hand of Reason—as yet sadly rickety on his legs—and showing him which way he should take. In the beginning of the moral life, again, we shall see how easily the realizing force of young imagination may expose its possessor to deception by others, and to self-deception too, with results that clearly simulate the guise of a knowing falsehood. On the other hand, a careful following out of the various lines of imaginative activity may show how moral education, by vividly suggesting to the child's imagination a worthy part, a praiseworthy action, may work powerfully on the unformed and flexible structure of a child's will, moving it dutyward.

The play of the young imagination meets us in the domain of sense-observation: a child is fancying when it looks at things and touches them, and moves among them. This may seem a paradox at first, but in truth there is nothing paradoxical here. It is an exploded psychological fallacy that sense and imagination are wholly apart. No doubt, as the ancients told us, fantasy comes of sense; we live over again in waking and sleeping imagination the sights and sounds of the real world. Yet it is no less true that imagination in an active constructive form takes part in the

very making of what we call sense-experience. We learn to read the visual symbol, a splash of light or color, now as a stone, now as a pool of water, just because imagination drawing from past experience supplies the interpretation, the group of qualities which composes a hard, solid mass, or a soft, yielding liquid.

Children's fanciful readings of things, as when they call the twinkling star a (blinking) eye, are but an exaggeration of what we all do. Their imagination carries them very much further. Thus they may attribute to the stone they see a sort of stone-soul, and speak of it as feeling tired.

This lively way of envisaging objects is, as we know, similar to that of primitive folk, and has something of crude Nature-poetry in it. This tendency is abundantly illustrated in the metaphors which play so large a part in children's talk. As everybody knows, a child describes what he sees or hears by analogy to something he knows already. This is called by some, rather clumsily, I think, apperceiving. For example, a small, oscillating compass needle was called by a child a bird, on the ground of a faint likeness of form and fluttering movement. M. Taine tells us of a little girl who called the eyelids prettily eye-curtains. Distant and unknown things, for example the moon, will naturally come in for much of this vivid imaginative interpretation. Thus the moon when reduced to a crescent was said by a boy of three to be broken. American children described it ingeniously as half stuck or half buttoned into the sky.* Similarly with sounds. The spluttering of coals in the fire was called barking by a little girl of four and a half years. The American children already referred to described thunder variously as a throwing down of toys, a shooting in of coals, and so forth.

This play of imagination in connection with apprehending objects of sense has a strong vitalizing or personifying element. That is to say, children, in common with uncivilized peoples, see what we regard as lifeless and soulless as alive and conscious. Thus a child will say a tree rustling in a cold wind "shivers." The tree is apprehended or "apperceived" as having sensation and behaving as the child itself behaves. Moving things come in for most of this personifying impulse. A little girl of five, pleased at being able to manage her hoop, said: "Mamma, I do b'lieve this hoop must be alive, it's so sensible; it goes where I want it to."

Children's fear of feathers, of which I have several instances, and which they have in common with uncultured folk, is proba-

* These were children entering the primary school of Boston, whose ideas are described by Dr. Stanley Hall, in an article on The Contents of Children's Minds, in the Princeton Review.

bly due to the uncanny look of a sort of ghost life as the light, unsubstantial thing slowly moves of itself from the ground and poises in mid-air. Perhaps a dog's uneasiness at the sight of leaves whisked in an eddy over the ground by the wind shows a degree of the same personifying instinct. Sometimes this endowment of things with sensation leads to a quaint manifestation of sympathy. Miss Ingelow writes of herself when a little over two years old and for about a year after: "I had the habit of attributing intelligence not only to all living creatures, the same amount and kind of intelligence that I had myself, but even to stones and manufactured articles. I used to feel how dull it must be for the pebbles in the causeway to be obliged to lie still and only see what was round about. When I walked out with a little basket for putting flowers in I used sometimes to pick up a pebble or two and carry them on to have a change; then at the farthest point of the walk turn them out, not doubting that they would be pleased to have a new view." *

This is by no means a unique example of a childish lavishing of pity on what we think the insentient world. Plant life seems often to excite the feeling. Here is a quotation from a parent's chronicle. A girl aged eight brings a quantity of fallen autumn leaves in to her mother, who says, "Oh! how pretty, F——!" to which the girl answers: "Yes, I knew you'd love the poor things, mother. I couldn't bear to see them dying on the ground." A few days afterward she was found standing at a window overlooking the garden, crying bitterly at the leaves as they fell in considerable numbers.

This is not the place to speak of the rich endowment of the animal world with human susceptibilities by the childish imagination. We all know how grotesquely the little humanitarian insists on fondling pussy, or wiping her nose, and otherwise tormenting that long-suffering quadruped, all from the kindest of motives.

Now it may be asked whether all this analogical extension of images to what seem to us such incongruous objects involves a vivid and illusory apprehension of these as transformed. Is the eyelid realized and even *seen* for the moment as a sort of curtain, the curtain image blending with and transforming what is present to the eye? Are the pebbles actually looked at as living things condemned to lie stiffly in one place? It is of course hard to say, yet I think a conjectural answer can be given. In this imaginative contemplation of things the child only half observes what is present to its eyes. One or two points of supreme interest in the visible thing, the falling of the leaf, the hiding of the eye by the

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* See her article The History of an Infancy. Longman's Magazine, February, 1890.

lid, are selectively attended to; and assimilative imagination, the overlaying of the visual impression with an image called up by similarity or analogy, does the rest. In this way the actual field of visible objects is apt to get veiled, its appearance being transformed by the wizard touch of a lively childish fancy.

No doubt there are various degrees of illusion here. In its matter-of-fact and really scrutinizing mood a child will not confound what is seen with what is imagined; in this case the analogy recalled is distinguished and used as an explanation of what is seen—as when a child observed of a panting dog, "Dat bow-bow like puff-puff." On the other hand, when another little boy aged three years and nine months, seeing the leaves falling exclaimed, "See, mamma, the leaves is flying like dickey-birds and little butterflies!" it is hard not to think that the child's fancy for the moment transformed what he saw into the pretty pictures. And one may risk the opinion that, with the little thinking power and controlling force of will which a child possesses, the chances are that such assimilative activity of imagination always tends in the young brain to develop a degree of momentary illusion.

It may be added that abundant evidence goes to show that children at first quite seriously believe that all things are alive and feel. A child starts from himself as the model of a thing, and mentally fashions other things like himself. He has slowly to learn the distinction between the living and the lifeless, the sentient and the insentient. No parent who has lived with his children could, I think, doubt this. Dr. Stanley Hall's inquiries have, among other curious results, shown that out of forty-eight little ones just attaining the school age, twenty believed the moon and stars to be alive, fifteen thought a doll and sixteen thought flowers would suffer pain if burned. Perhaps a good many more had a secret belief to the same effect, but through shyness and a shrewd half-guess of the drift of the question declined to be drawn into a categorical statement. The animism of children is apt to get laughed at, and as soon as that begins they become reserved and secretive of the "contents" of their minds.

There is another way in which imagination may combine with and transform sensible objects, viz., by what is commonly called association. Mr. Ruskin tells us that when young he associated the name crocodile with the creature so closely that the long series of letters took on something of the look of the lanky creature. The same writer in his Præterita tells of a Dr. Grant into whose therapeutic hands he fell when a child. "The name" he adds, "is always associated in my mind with a brown powder—rhubarb or the like—of a gritty or acrid nature. . . . The name always sounded to me gr-r-ish and granular."

We can most of us, perhaps, recall similar experiences, where colors and sounds, in themselves indifferent, took on either through analogy or association a decidedly repulsive character. How far, one wonders, does this process of transformation of things go in the case of imaginative children? There is some reason to say that it may go very far, and that, too, when there is no strong feeling at work cementing the combined elements. A child's feeling for likeness is commonly keen and subtle, and knowledge of the real relations of things has not yet come to check the impulse to this free, far-ranging kind of assimilation. Dickens was not, one feels sure, the only child who saw odd resemblances in letters, finding, for example, that the thick O and S of his primer stood out from the rest as the easy, good-natured ones. This sort of fanciful reading of character into things is of the very life of childhood. Before the qualities and the connections of objects are sufficiently known for them to be interesting in themselves, they can only acquire interest through the combining art of childish fancy. And the same is true of associated characters. A child's ear may not dislike a grating sound, a harsh noise, as our ear dislikes it, because of its immediate effect on the sensitive organ. *En revanche* it will like and dislike sounds for a hundred reasons unknown to us, just because the quick, strong fancy, adding its life to that of the senses, gives to impressions much of their significance and much of their value.

There is a new field of investigation which is illustrating in a curious way this wizard influence which childish imagination wields over the things of sense. It is well known that a certain number of people habitually color the sounds they hear, visualizing the sound of a vowel, or of a musical tone, as having its characteristic tint which they are able to describe accurately. This "colored hearing," as it is called, is always traced back to the dimly recalled age of childhood. Children are now beginning to be tested, and it is found that a good proportion possess the faculty. Thus in the researches on the Boston children already referred to it was found that out of fifty-three, twenty-one, or nearly one half, described the tones of certain instruments as colored. The particular color, as also the degree of its brightness, ascribed to an instrument, varied greatly among different children, so that, for example, one child visualized the tone of a fife as pale or bright, while another imaged it as dark.* It is highly probable that both analogy and association play a part here.† As was recently suggested to me by a correspondent, the classic instance of the anal-

* See the article, Contents of Children's Minds, already quoted, pp. 265, 266.

† This has been well brought out by Prof. Flournoy, of Geneva, in his volume, Des Phénomènes de Synopsie (audition colorée), chap. ii.

ogy between scarlet and the note of a trumpet may easily be due, in part at least, to association of this tone with the scarlet uniform.

I may add that I once happened to overhear a little girl of six talking to herself about numbers in this wise: "Two is a dark number, forty is a white number." I questioned her, and found that the digits had each its distinctive color, thus: "one," white; "two," dark; "three," white; "four," dark; "five," pink, and so on. "Nine" was pointed and dark, "eleven" dark green, showing that some of the digits were much more distinctly visualized than others. Just three years later I tested her again and found she still visualized the digits, but not quite in the same way. Thus, although "one" and "two" were white and black as before, "three" was now gray, "four" red, "five" pink, "nine" had lost its color, and "eleven," oddly enough, had turned from dark green to bright yellow.

This case suggests that in early life new experiences and associations may modify the tint and the shade of sounds. However this be, children's colored hearing is worth noting as the most striking example of the general tendency to supplement and to overlay sense-impressions with vivid images. It seems reasonable to suppose that colored hearing and other allied phenomena, as the picturing of numbers, days of the week, etc., in a certain scheme or diagrammatic arrangement, when they show themselves after childhood, are to be viewed as survivals of early fanciful brain work. This fact, taken along with the known vividness of the images in colored hearing, which in certain cases approximate to sense-perception, seems to me to confirm the view here put forth, that children's imagination may alter the world of sense in ways which it is hard for our older and stiff-jointed minds to follow.

I have confined myself here to what I have called the *play* of imagination, the magic transmuting of things through the sheer liveliness and wanton activity of a child's fancy. How strong, how vivid, how dominating such imaginative transformation may become will of course be seen in cases where violent feeling, and especially fear, gives preternatural intensity to the realizing power of imagination. But this effect of emotion is too large a subject to deal with here.

This playful transformation of the actual surroundings is, of course, restrained in serious moments and in intercourse with older and graver folk. There is, however, a region of child life where it knows no check; where the impulse to deck out the shabby reality with what is bright and gay has it all its own way. This region is Play. In another article, with the permission of the editor, I hope to take up the subject of children's play, considered as an expression of their imaginative activity.

A COLONIAL WEATHER SERVICE.

By ALEXANDER McADIE, M. A.

THE Signal Service was thoroughly organized as a meteorological body in November, 1870. As Americans we are justly proud of the work accomplished by it and its immediate successor the Weather Bureau. Toward the establishment and success of the meteorological service the army, the navy, and civil life contributed representative men: Myer, the soldier physician, dubbed by his countrymen "Old Probs"; Maury, the seaman whose pen could trace on many pages descriptions ever pleasing and instructive; and Ferrel, citizen professor amid military men, one so diffident and reserved that he carried to and from the meetings of the National Academy, of which he was a member, manuscripts of problems *solved*, which he would have liked to make known but that a strange shyness prevented. Forecasting weather changes had, however, been suggested earlier than the date above given. It is said that the French war office, during the siege of Sevastopol, sent to the allied fleets before the fortress information that a tempest was raging west of the Crimean Peninsula. In the United States, Redfield, Espy, Coffin, Loomis, Henry, and Lapham had argued the possibility of forecasting weather changes if systematic simultaneous observations could be had. Antedating all of these stands that unique philosopher, the printer of Philadelphia, who had discovered, before the middle of the eighteenth century, that "our northeast storms come from the northwest." Before Franklin, however, came his correspondent, Dr. John Lining, of Charleston, S. C., who kept a record of the daily temperature in 1738. Thermometers had then been in use but a few years. But the observations which were the most remarkable of all, and which up to the present time have been unnoticed if not indeed unknown, were made in Virginia about the time of the Revolution. The observers were James Madison, styled by that charming old traveler, the Marquis de Chastellux, "an eminent professor of mathematics"; and Thomas Jefferson, the Sage of Monticello. One was at Williamsburg, the colonial capital, practically near the sea; the other at Monticello, one hundred and twenty miles west and north, practically in the mountains.*

These two colonial gentlemen operated a weather service; on a small scale it is true, but the observers seem to have clearly recognized that great underlying principle of all modern weather

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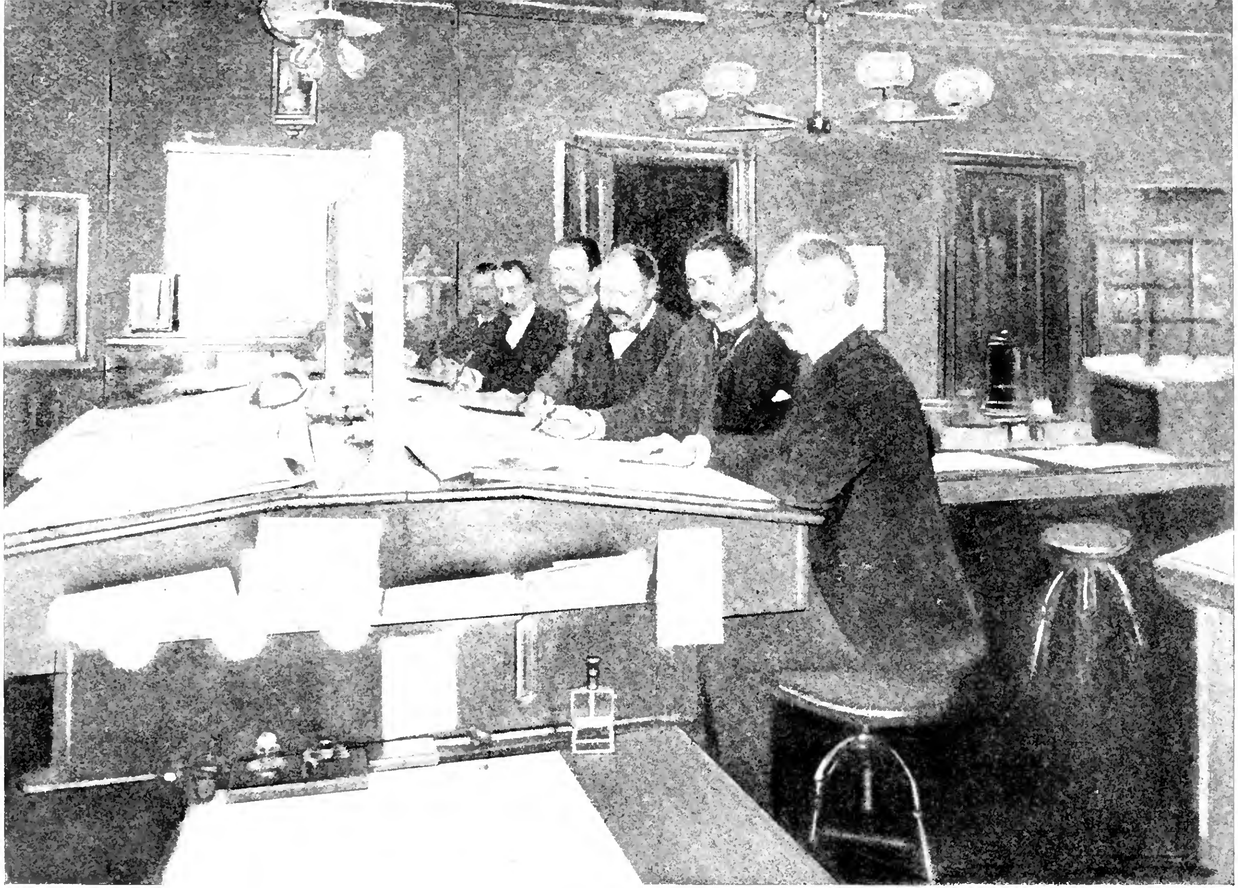
* A voluminous correspondence between the two is on file in the State Department, access to which was kindly granted by the Secretary of State.



Forecasters at Work, in Washington.

bureaus, the taking of observations *simultaneously*. This, if established, removes the palm of priority from Le Verrier and France to our own country. True, no map was issued; but a century before either Le Verrier or the Signal Service, the principle which makes the map possible was thought out and tried with the best agencies at hand. Had the telegraph been in existence, there is no telling what these acute-minded colonists would have attempted.

Madison was by training and inclination a man of science, and no one can disparage Jefferson's activity as an observer. It was the practice of the latter to read his thermometer every day either at sunrise or at nine in the morning, and at sunset or four in the evening. Even the calls so frequently made upon him for active service elsewhere, while interrupting the Monticello records, did not prevent his taking observations as he journeyed. In his private expense account * we find records of temperature, rainfall, and weather jotted down with as much care and detail as expenditures. In some pages at the end of the book, the title-page of which reads, "The Philadelphia Newest Almanac for the Year of our Lord 1776, being Leap Year. . . . By Timothy Telescope, Esq." Jefferson has noted for the years 1776, 1777, and 1778 his personal expense items and detailed systematic records of temperature and rain. We turn the pages of this rare old diary slowly and there are some entries on which the eye lingers, while one wonders why these pages have not received the attention of historian and meteorologist.

On July 4, 1776, he jotted down among his expenses:

pd. Sparhawk for a thermometer..................	£3 /15
pd. for 7 pair of women's gloves..................	/27
gave in charity..............................	1/ 6

And on July 8th the same year:

pd. Sparhawk for a barometer....................	£4 /10
pd. 2 dinners at Smith's........................	18/ 6

Sparhawk, I surmise, was an instrument-maker, and the price paid for the thermometer indicates an instrument of high order. From intimations in various places one can almost believe that the purchase of this high-priced instrument was regarded by Jefferson as an act of self-indulgence. Whether it served to relieve the mental strain incident to the doings of that ever-memorable week, or whether he was simply eager to study the new acquisition, certain it is that the entries are more than usually frequent.

* These MSS. are in the possession of the family at Edge Hill, Va., to whom I am indebted for many kindnesses.

There, in Jefferson's own fine hand, stands the record of his observations:

	HOUR.	THERM.		HOUR.	THERM.
1776, July 1:	9.00 A. M.	$81\frac{1}{2}°$	July 3:	1.30 P. M.	76°
	7.00 P. M.	82°		8.10 P. M.	74°
July 2:	6.00 A. M.	78°	July 4:	6.00 A. M.	68°
	9.40 A. M.	78°		9.00 A. M.	$72\frac{1}{4}°$
	9.00 P. M.	74°		1.00 P. M.	76°
July 3:	5.30 A. M.	$71\frac{1}{2}°$		9.00 P. M.	$73\frac{1}{2}°$

The fourth of July, 1776, was, then, relatively cool. I think statements to the contrary have been made, and the day described as hot and sweltering. More than one historian may have drawn upon imagination in describing the weather of those first days in July when the signers of the Declaration were gathered together in Philadelphia. Strange that from the same hand that penned the Declaration should come at this late date a true statement of the weather of that period. One can not help a feeling of surprise that Jefferson, with so many duties pressing, should have found time to make these detailed observations.

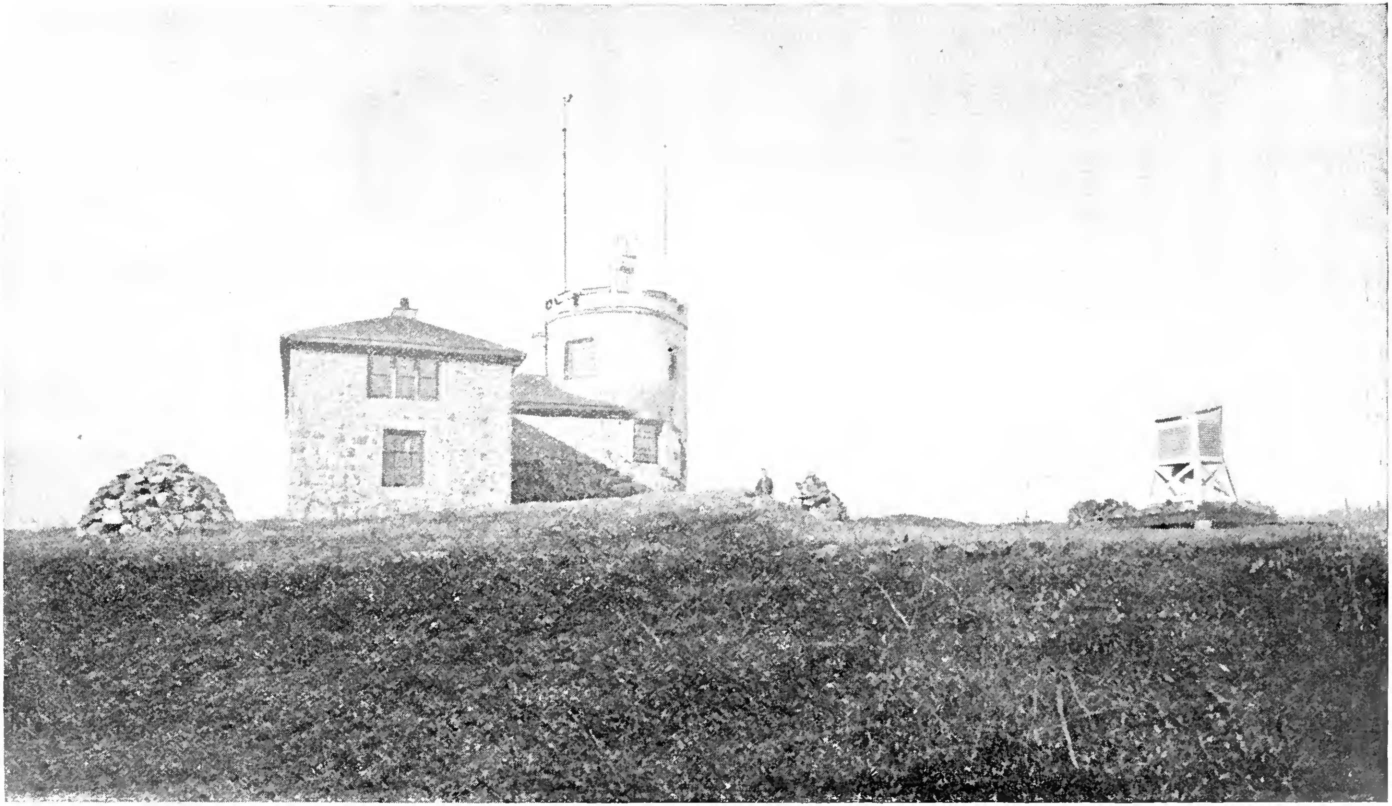
The Colonial Weather Service experienced all the vicissitudes of war. Madison writes to Jefferson somewhat pathetically as follows:

"I wish we had a barometer; but there is no possibility of getting one here at present. *The British robbed me of my thermometer and barometer.*" This must have been a serious loss to the colonial meteorologists, although to us there is a touch of the ludicrous in the very idea of British soldiery relieving the college professor of his thermometer and barometer. Perhaps the instruments would have been spared could the commanding officer have foreseen that in a few years, the war ended and the colonies independent, this very professor was to go to England and be consecrated as Bishop of Virginia.

But notwithstanding interruptions, our meteorologists persevered, and their long-continued correspondence is full of *wherefores* and *whys* which even at this day are of interest and meaning. They ascertained "by contemporaneous observations of between five and six weeks" that "the averaged and almost unvaried difference of the height of mercury in the barometer at these two places was 0·784 of an inch; the pressure at Monticello being so much the lightest—that is to say, about a thirty-seventh of its whole weight.*

Furthermore—and this is truly remarkable—they proved in their own words "the variations in the weight [meaning pressure] of the air to be *simultaneous and corresponding in these two places.*" Many data were collected regarding the climate of Vir-

* Notes on Virginia, second American edition, Philadelphia, November 12, 1794.



A Modern Meteorological Observatory.

ginia. The value of the work can be judged by Jefferson's statements under Query 7 in his Notes on Virginia:

"Journals of observations on the quantity of rain and degree of heat being lengthy, confused, and too minute to produce general and distinct ideas, I have taken five years' observations, to wit from 1772 to 1777, made in Williamsburg and its neighborhood, have reduced them to an average for every month in the year, and stated those averages in the following table, adding an analytical view of the winds for the same period."

Then follows quite a long table of average temperatures and wind directions of great interest to the meteorologist. Thinking that some noteworthy differences might exist between the northeast and northwest winds at the two stations, a second table was constructed by reducing observations at the two places for nine months to the "four points perpendicular to and parallel to the coast. It may be seen that the southwest wind prevails equally at both places, that the northeast is next to this the principal wind toward the seacoast, and the northwest is the predominant wind toward the mountains; . . . the northeast wind is loaded with vapor insomuch that the salt-makers have found that their crystals would not shoot while that blows; it brings a distressing chill, and is heavy and oppressive to the spirits; the northwest is dry, cooling, elastic, and animating."

Even our valuable Crop Bulletin was foreshadowed by these early workers. We find it recorded that "white frosts are frequent when the thermometer is at 47° and have killed young plants of Indian corn at 48°, and have even been known at 54°. Black frost and even ice have been produced at 38½°."

Finally, that much-discussed matter, change in climate, did not escape their notice. "A change in climate," they claim, "is taking place very sensibly." This was written in 1781. "Both heats and colds are becoming much more moderate within memory even of the middle-aged. Snows are less frequent and less deep. They do not often lie below the mountains more than one, two, or three days, and very rarely a week."

And then follows a very evident reference to that even then well-known personage, *the oldest inhabitant:*

"The snows are remembered to have been formerly frequent, deep, and of long continuance. The elderly inform me that the earth used to be covered with snow about three months in every year."

From snows and winds these meteorologists turned their attention to rainbows, and from rainbows to water vapor and steam. Curiously enough, it is in a letter to Jefferson, mostly about the rainbow, that Madison gives the latest information about a boat to be propelled by steam and which "General W——

and others have seen and approved, and is much discussed by the well-informed; but which I must say *I feel skeptical about.*"

What a contrast! The steam navigation of that date and to-day; from the first rude paddles of the river steamboat to the triple screws of the transatlantic greyhounds! One naturally asks, "Are we to-day on the verge of a still greater navigation, that of the air?" No modern Madison may yet write that some General W—— has seen and approved, but the signs of its advent are multiplying so rapidly that he would not say, "I feel skeptical about it." If these two alert minds were again on earth, we can fancy Jefferson, always so keenly alive to practical application of knowledge, discussing the outlook as follows:

The meteorologists are exultant. In that latest instrument of the electrical engineer, the telautograph, they see the chance for an advance equal to that made when the first synoptic weather map was drawn. Simultaneity of observation can be improved upon. Instead of sending the observations in cipher twice or thrice per day, *continuous records in installments* can be sent. But even more than this, the map can be drawn *in many places at once.* The map is issued daily at a score of cities in the United States. A map is also issued daily at Brussels, Paris, London, Zurich, Hamburg, Rome, Munich, Vienna, Chemnitz, Madrid, Algiers, St. Petersburg, Simla, Brisbane, Sydney, Tokio, and Cape Town. Now one step further. *Shall there ever be one great central weather office and one great daily weather map for the whole world, drawn not in one but a hundred cities at the same moment?* Does this seem visionary? It is vastly less so than the actual system in operation for the past twenty years would have seemed to the two colonial gentlemen who more than a century ago read their barometers and thermometers *simultaneously* and speculated on the possibility of propulsion by steam.

Viewing exact delineation by trigonometrical measurement as the crowning work of geography, Mr. Clements R. Markham pointed out, in a recent lecture, that the exact mapping of the land surface of the globe is still very incomplete, while the delineation of the bed of the ocean has hardly begun. The greatest unknown areas lie in the polar regions Even in Europe there remains scope for detailed survey in many countries. In Africa the unexplored has been diminishing very rapidly, but considerable areas are still virgin. Asia has much new ground to break into. The valleys of Hadramaut in Arabia are almost as little known as the antarctic regions. Lhassa has been unvisited by Englishmen for generations, and a vast region in northwestern Thibet is still a blank on our maps. Nepaul is little known; Kafiristan is absolutely secluded from the European. The maze of mountain ranges and river valleys east of the Himalayas has yet to be unraveled, and the whole interior of Indo China is full of opportunities for research. Korea is yet far from being fully known. The great Malay Archipelago must receive more attention.

HOMES OF SOCIAL INSECTS.*

By L. N. BADENOCH.

IN no branch of insect work are more admirable means employed to bring about the desired ends, or is greater diversity of method found, than in that of insect architecture. The beauty of the buildings in many cases is incomparable, and generally speaking the abodes attain a magnitude colossal as compared with that of their creators. It may be exception will be taken to the use of the word architecture to designate this portion of the insect economy, and perhaps the term can hardly be applied in fairness to homes which are mere tunnels and galleries bored in the earth or in wood. But who would deny it to the exquisite pensile nests of the English wasps, or those of many a foreign relative, to the geometric precision exhibited within the hive of the honey bee, or to the edifices of some ants, as will be presently discovered?

Among the communities which combine their operations, there are those of which the object is simply the protection of the individuals composing them. To these societies belong the caterpillars of certain species of moths. The homes formed by these larvæ, though they are not elaborate, are interesting in several minute circumstances. But they fall short in every respect of the attractive nests fabricated by companies of insects in their perfect state, in view not only of self-preservation, but of the nurture and education of their young as well.

The nests of an extraordinary tree ant, *Œcophylla smaragdina*, are cunningly wrought with leaves, united together with web (see Fig. 1). One was observed in New South Wales in the expedition under Captain Cook. The leaves utilized were as broad as one's hand, and were bent and glued to each other at their tips. How the insects manage to bring the leaves into the required position was never ascertained, but thousands were seen uniting their strength to hold them down, while other busy multitudes were employed within in applying the gluten that was to prevent them returning back. The observers, to satisfy themselves that the foliage was indeed incurvated and held in this form by the efforts of the ants, disturbed the builders at their work, and as soon as they were driven away the leaves sprang up, with a force much greater than it would have been deemed possible for such laborers to overcome by any combination of strength. The more compact and elegant dwelling of *Œ. vires-*

* Reprinted, with the kind permission of Messrs. Macmillan & Co., from the author's popular work, Romance of the Insect World.

cens is made of leaves, cut and masticated until they become a coarse pulp. Its diameter is about six inches; it is suspended among thickest foliage, and sustained not only by the branches on which it hangs, but by the leaves, which are worked into the composition, and in many parts project from its outer wall. It may be at once distinguished from the nest of *Crematogaster* by its smoothness and regularity of surface. A species of this genus was discovered in Africa by Foxcroft, who observed that whenever the ants were molested, they rushed out of their house

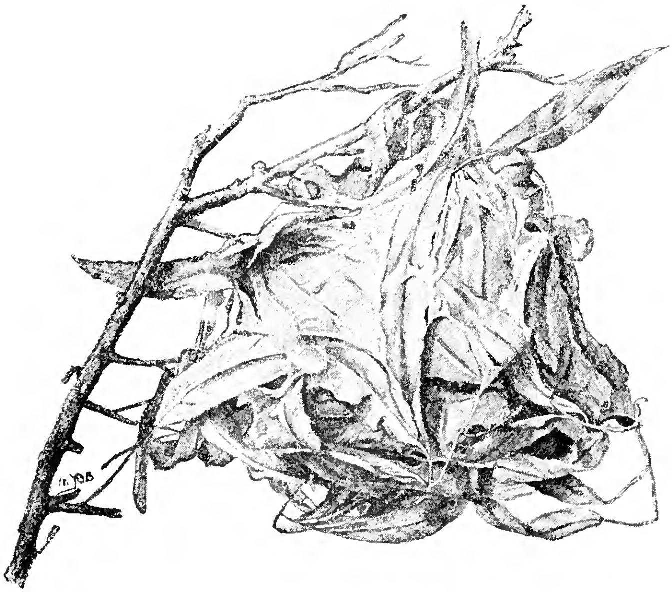


FIG. 1.—NEST OF A TREE ANT (ŒCOPHYLLA SMARAGDINA) FROM INDIA.

in such numbers that their pattering upon the papery covering deluded him into thinking rain was falling on the leaves above.

In the forests of Cayenne, the nests of *Formica bispinosa* are remarkably like a sponge or an overgrown fungus. The down or cottony matter enveloping the seeds in the pods of the *Bombax ceiba* is used for their construction, vegetable fibers that are too short to convert into fabrics, but which the ants contrive to felt and weave into a compact and uniform mass, so dexterously that all trace of the individuality of the threads is lost. The material much resembles amadou, and like that substance is valuable for stopping violent discharges of blood. In size the nests generally have a diameter of eight or nine inches. The ant itself is little and dark, and noted for two long, sharp spines on its thorax, one on either side; hence its scientific name of *bispinosa*, from the Latin, meaning two-spined. Popularly it has been called the fungus ant.

The true social wasps, which are arranged in one large family, the *Vespidæ*, form communities whose architectural labors will not suffer on comparison even with those of the inhabitants of the beehive. In fact, for daintiness and delicacy the nests of many of the *Vespidæ* constitute the most beautiful examples of insect architecture.

Not the least extraordinary of the wasps are the *Icarias*, a genus that extends through most of the warmer regions of the world, specimens having been taken in Africa, India, China, and Australia, and in many parts of the Asiatic Archipelago. Like the *Polistes*, their nests are attached to leaves, stalks, or branches by a single footstalk, composed of the same papery material as the cells. Though slender, it is hard, tough, and solid, and the strength with which it is fastened to the tree or plant is surprising, enabling it to uphold considerable weight. At the end of the petiole usually a single cell, its mouth directed downward, is fixed; the rest of the nest consists of a double series of lateral cells until the group is complete. Those nearest to the footstalk are the largest and most perfect, since they are finished first; toward the other extremity the cells gradually diminish in size, and at that point they are only just begun. As a whole they are well-defined hexagons; their color is often a rather dark yellowish brown, preventing them from being conspicuous in spite of their curious projection. The cell masses are small, so that the societies must be restricted. Possibly each group is the work of a single female, who confines herself to raising her own progeny which escape as soon as they are hatched. The nests are frequently numerous in the same spot, and each society may set up a number of separate homes in the vicinity of one another. Per-

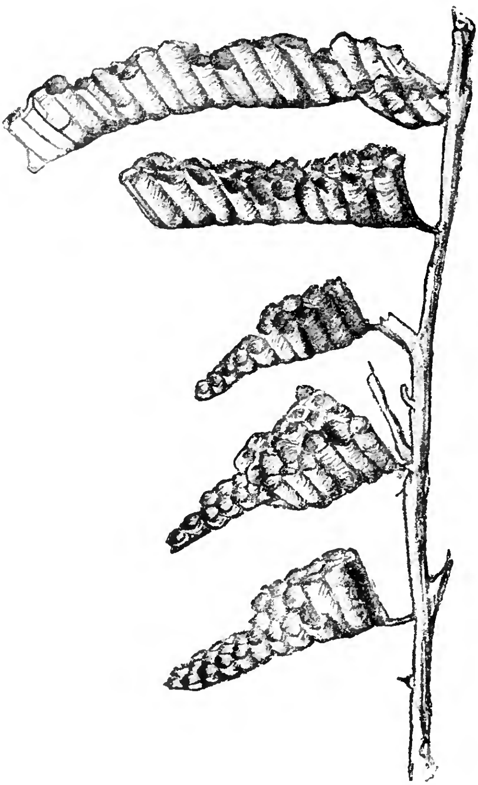


Fig. 2.—Nest of Icaria variegata.

haps in this genus, as among the *Polistes*, workers are wanting (see Fig. 2).

The wasps hitherto considered are distinguished as manufacturers of paper, in general fine and thin and more or less brittle, the weakness of which they overcome by the superposition of a great number of leaves. There is a large class who, while they make many kinds of papyraceous tissues, are noted for a feature in common—the fabrication of a solid and tough paper, a veritable cardboard, composed of only one layer of material, at times very thick and resisting, at others slight and supple. Of this substance, after the manner of *Vespa*, the wasps usually build a papyraceous envelope or sac for the inclosure of their combs, and as in that genus, the covering follows closely the direction of the plan of the cells.

The genus *Chartergus*, one of the important groups of the cardboard makers, includes insects apparently similar which practice two strangely different forms of nidification. The nests of *C. chartarius*, the most common in collections, are of frequent occurrence in tropical America. Their cardboard is white, gray, or of a buff color, tending to yellow, very fine and of polished smoothness; at the same time it is strong and so solid as to be impervious to the weather. It can not be urged sufficiently, says Réaumur, that this kind of envelope is indeed of a veritable cardboard, as beautiful as any we know how to make. Réaumur once showed a piece to a cardboard manufacturer, and not the slightest suspicion of its real nature was suggested to his mind. He turned it over and over, he examined it thoroughly by the touch, he tore it, and after all declared it to be made by one of his own profession, mentioning manufacturers at Orleans as the probable producers. The nests may be conical or cylindrical, they may be straight, but more often are somewhat curved; some are almost globe-shaped, but these varieties are of little importance. The length of a well-sized nest is about a foot; the largest yet discovered was in Ceylon, and measured the astonishing size of six feet. The edifice is pendulous on trees and attached, as it were, to a suspensory ring, which embraces the branch and is tightly impasted round it, or, according to Westwood, may be large compared with the latter's circumference; but it is probably a mistake to say that the nest ever swings freely as on a pivot. The interior consists of circular concave horizontal platforms of cells, their mouths turned downward, each tier stretching right across like so many floors, and fastened along its entire edge to the walls. Communication is effected by a central opening through the bottom and through every tier. When the number of inhabitants becomes very great and a fresh series of cells is added, unlike the British wasps who add to their abodes by a preliminary in-

crease of the envelope to admit of extension of the tiers, the *Chartergi* go to work on precisely the opposite plan, first forming new cells and covering them afterward. Taking the bottom of the nest as a starting point, they set cells over its exterior surface, being careful to extend the circumference by a row or two to

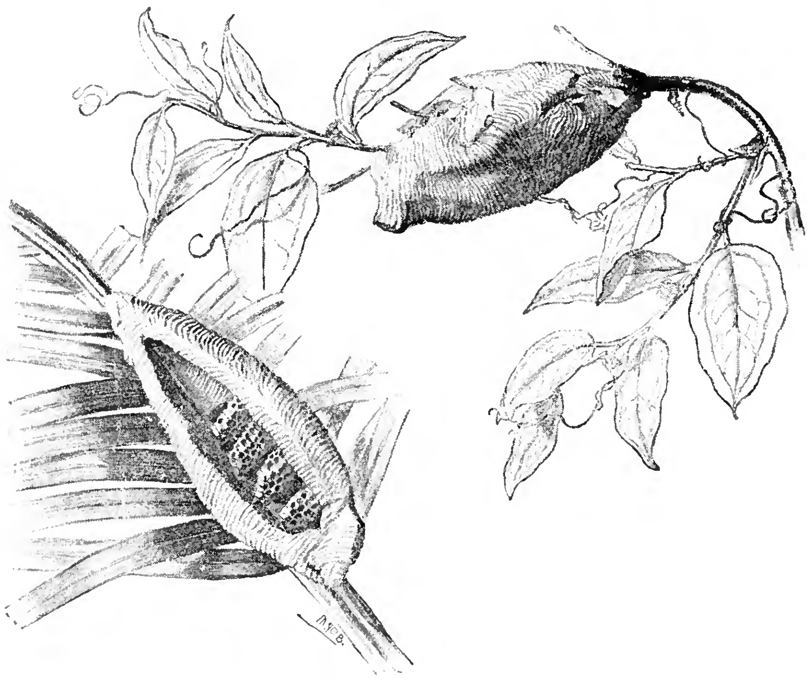


Fig. 3.—Wasp's Nest (Chartergus apicalis), Interior and Exterior.

augment the diameter in proportion to the length, so that the symmetry of the building may not be lost. The walls are then lengthened to include the fresh stage, and the end is closed with a new floor, in its turn to become the ceiling of the next tier of cells when further enlargement is desired. No trace of the addition is visible on the outside of the envelope, which would seem constructed at one stroke.

The other kind of nest of *Chartergus* is constructed on a straight and upright branch, having no lateral twigs. Its elegance can not be sufficiently admired. Composed of a few cells only, the combs are attached to the branch by means of petioles, or solid masses of wax, keeping the groups in a horizontal and parallel position. They stand one over the other, sometimes to the number of ten, separated by considerable intervals, and so admirably upheld by the petioles that the aid of all pillars or columns is dispensed with. The envelope is a spindle of a single leaf of ligneous paper, most artistic in appearance, being marked with

transverse parallel tubings and goffered. The fibers of the tissue are arranged with surprising regularity; all the zones are united with consummate art, and meet in a long and plainly shown line; the paper may be also variegated with longitudinal bands of different colors. The vase is firmly fixed to its axis at points slightly above and below the uppermost and lowermost combs; at no part is it in continuity with the combs; there is plenty of space between the two fabrics for the wasps to pass up and down within their home with ease. Taking advantage of the wholly lateral position of the combs with respect to the axis, the wasps render their building less fragile than it would otherwise have been by placing the branch to one side of the spindle, and it saves time and trouble, without materially impairing the support, to leave the wood exposed at the posterior surface of the papery mass. The opening is small and situated at the lower end (see Fig. 3).

Very extraordinary are some of the nests in the collection of the British Museum—the works of *Myrapetra scutellaris* (see

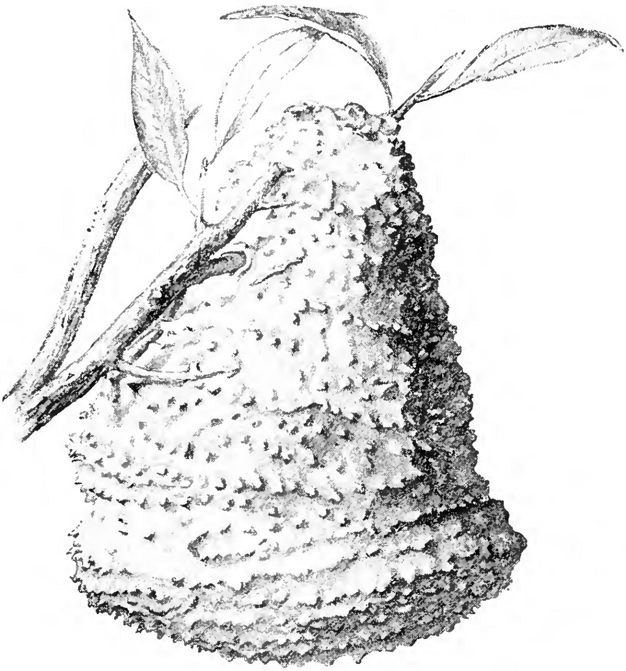


Fig. 4.—View of Exterior of Nest of Myrapetra scutellaris.

Fig. 4), a mere fanciful title. These huge erections are from Central America, and the native authorities say of one that it is not composed of wood fibers, but of the dung of the capincha, one of the aquatic cavies of the region. One's attention is instantly attracted to the fairly conical knobs or tubercles with

which the surface is thickly beset, of various size, and most pointed where they are least exposed. Their disposition is in horizontal zones, seeming to correspond more or less with the comb tiers. While at the top of the nest they are comparatively few, gradually the numbers increase toward the lower end, and on the bottom they are so numerous that one's finger can scarcely be laid between them. Like the envelope, they are made up of several papery layers so closely blended as to be hardly distinguishable, forming a substance astonishingly thick, hard, and firm, in color of a dull dark brown, and of very coarse texture. Of what use they are it is difficult to decide; they may be simply

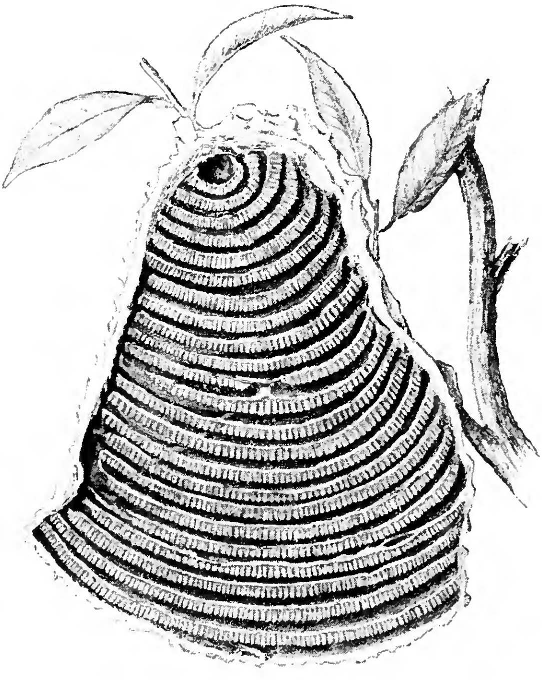


Fig. 5.—View of Interior of Nest of Myrapetra scutellaris.

freaks of Nature. Although their tips are not acute, they may defend the abode against the attacks of tigers, jaguars, kuguars, and other mammalia partial to honey and the grubs of the hive. The nest always hangs low, seldom more than three or four feet from the ground, and protection would appear much needed. It seems hardly possible to deny that they are for the double purpose of concealing and of sheltering the entrances, which are invisible when the nest is looked at from above. Examination reveals them beneath a row of the projections, which overhang them and keep off the rains like the eaves of a house; the passages are also intricately twisted, so as to prevent the ingress of

moths or other enemies of any size. It is strange that the interior surface of the nest is provided with tubercles, a circumstance that must put the insects to the trouble of gnawing them away each time they add a stage. Probably the same material is again employed in establishing fresh cells and in building the new platform.

A longitudinal section shows the peculiar disposition of the combs. Just as in the spherical nests of *Polybia*, the highest ones are perfect or almost perfect spheres; but this method of construction is soon found to be too laborious. A nearly globular mass of the brown paperlike substance exists at the top—the nucleus, so to speak. The first combs closely surround this, so that they form the best parts of hollow spheres; then come great arcs of circles, followed in regular order by other tiers, their rotundity becoming gradually reduced until the curve of the lower ones is extremely shallow, exactly like the tiers of *Tatua*, except that they exhibit a trifling convexity on their lower surfaces. They are carried to the common wall and thereto affixed, small spaces being left open here and there between their edges and the envelope. The solid wall at the top is of great thickness (see Fig. 5).

In the nest in the British Museum already described, a quantity of brownish-red honey was found in the upper combs, but hard and dry. Even so long ago as the beginning of the century, Azara, a Spanish officer, who was sent out by his Government to Paraguay to make certain investigations in that country, mentions that a South American wasp which he calls chiguana has the strange habit of hoarding honey. The chiguana of Azara, it would seem, is identical with *Polybia scutellaris*. At the time of publication Azara's statement was not believed, so opposed was the habit that he claimed for this insect to the known actions of wasps. He and his men ate from the chiguana's store, and it proved deleterious. St. Hilaire, a subsequent traveler, speaks of two South American honey wasps. The honey of one was white and innocuous, that of the other was reddish brown and poisonous. The good honey was in an oval, light-colored nest of thin, papery material, totally different from the paper of *Myrapetra*, and was observed by Hilaire on a small bush near Uruguay, at a distance of only about a foot from the ground. This wasp has been described as lecheguana. Probably under the term lecheguana, or chiguana, as Azara has it, the inhabitants of America confound many wasps of similar kinds, and it is rather a generic title for all honey wasps than for one species in particular.

LATITUDE AND VERTEBRÆ.

A STUDY IN THE EVOLUTION OF FISHES.

By DAVID STARR JORDAN.

IN this paper is given an account of a curious biological problem and of the progress which has been made toward its solution. The discussion may have a certain popular interest from the fact that it is a type of many problems in the structure and distribution of animals and plants which seem to be associated with the laws of evolution. In the light of these laws they may be more or less perfectly solved. On any other hypothesis than that of organic evolution the solution of the present problem, for example, would be impossible. On the hypothesis of special creation a solution would be not only impossible but inconceivable.

It has been known for some years that in several groups of fishes (wrasse fishes, flounders, and "rock cod," for example) those species which inhabit northern waters have more vertebræ than those living in the tropics. Certain arctic flounders, for example, have sixty vertebræ; tropical flounders have, on the average, thirty. The significance of this fact is the problem at issue. In science it is assumed that all facts have significance, else they would not exist. It becomes necessary, then, to find out first just what the facts are in this regard.

Going through the various groups of nonmigratory marine fishes we find that such relations are common. In almost every group the number of vertebræ grows smaller as we approach the equator, and grows larger again as we pass into southern latitudes.

It would be tedious to try to prove this here by statistical tables, but the value of generalization in science depends on such evidence. This proof I have elsewhere * given in detail. Suffice it to say that, taking an average netful of fishes of different kinds at different places along the coast, the variation would be evident. At Point Barrow or Cape Farewell or North Cape a seineful of fishes would perhaps average eighty vertebræ apiece, the body lengthened to make room for them; at Sitka or St. Johns or Bergen, perhaps, sixty vertebræ; at San Francisco or New York or St. Malo, thirty-five; at Mazatlan or Pensacola or Naples, twenty-eight; and at Panama or Havana or Sierra Leone, twenty-five. Under the equator the usual number of vertebræ in shore fishes is

* In a more technical paper on this subject entitled Relations of Temperature to Vertebræ among Fishes, published in the Proceedings of the United States National Museum for 1891, pp. 107–120. Still fuller details are given in a paper contained in the Wilder Quarter-Century Book, 1893

twenty-four. Outside the tropics this number is the exception. North of Cape Cod it is virtually unknown.

The next question which arises is whether we can find other conditions that may affect these numbers. These readily appear. Fresh-water fishes have in general more vertebræ than salt-water fishes of the same group. Deep-sea fishes have more vertebræ than fishes of shallow waters. Pelagic fishes and free-swimming fishes have more than those which live along the shores, and more than localized or nonmigratory forms.* The extinct fishes of earlier geological periods had more vertebræ than the corresponding modern forms which are regarded as their descendants. To each of these generalizations there are occasional partial exceptions, but not such as to invalidate the rule.

All these effects should be referable to the same group of causes. They may, in fact, be combined in one statement. All other fishes have a larger number of vertebræ than the marine shore fishes of the tropics. The cause of the reduction in numbers of vertebræ must therefore be sought in conditions peculiar to the tropical seas. If the retention of the primitive large number is in any case a phase of degeneration, the cause of such degeneration must be sought in the colder seas, in the rivers, and in oceanic abysses. What have these waters in common that the coral reefs, rocky islands, and tide pools of the tropics have not?

In this connection we are to remember that the fewer vertebræ indicates generally the higher rank. When vertebræ are few in number, as a rule each one is larger. Its structure is more complicated, its appendages are larger and more useful, and the fins with which it is connected are better developed. In other words, the tropical fish is more intensely and compactly a fish, with a better fish equipment, and in all ways better fitted for the business of a fish, especially for that of a fish that stays at home.

In my view the reduction in number and increase of impor-

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* This is especially true among those fishes which swim for long distances, as, for example, many of the mackerel family. Among such there is often found a high grade of muscular power, or even of activity, associated with a large number of vertebræ, these vertebræ being individually small and little differentiated. For long-continued muscular action of a uniform kind there would be perhaps an advantage in the low development of the vertebral column. For muscular alertness, moving short distances with great speed, the action of a fish constantly on its guard against enemies or watching for its prey, the advantage would be on the side of few vertebræ. There is often a correlation between the free-swimming habit and slenderness and suppleness of body, which again is often dependent on an increase in numbers of the vertebral segments. These correlations appear as a disturbing element in the problem rather than as furnishing a clew to its solution. In some groups of fresh-water fishes there is a reduction in numbers of vertebræ, not associated with any degree of specialization of the individual bone, but correlated with simple reduction in size of body. This is apparently a phenomenon of degeneration, a survival of dwarfs where conditions are unfavorable to full growth.

tance of the individual vertebræ are simply part of this work of making a better fish. Not a better fish for man's purposes—for Nature does not care a straw for man's purposes—but a better fish for the purposes of a fish. The competition in the struggle for existence is the essential cause of the change. In the center of competition no species can afford to be handicapped by a weak backbone and redundant vertebræ. Those who are thus weighted can not hold their own. They must change or perish.

The influence of cold, darkness, monotony, and isolation is to limit the struggle for existence, and therefore to prevent its changes, preserving through the conservation of heredity the more remote ancestral conditions, even though they carry with them disadvantages and deficiencies. The conditions most favorable to fish life are among the rocks and reefs of the tropical seas. About the coral reefs is the center of fish competition. A coral archipelago is the *Paris* of fishes. In such regions is the greatest variety of surroundings, and therefore the greatest number of possible adjustments. The struggle is between fish and fish, not between fishes and hard conditions of life. No form is excluded from the competition. Cold, darkness, and foul water do not shut out competitors, nor does any evil influence sap the strength. The heat of the tropics does not make the water hot. It is never sultry nor laden with malaria. The influence of tropical heat on land animals is often to destroy vitality and check self-activity. It is not so in the sea.

From conditions otherwise favorable in arctic regions the majority of competitors are excluded by their inability to bear the cold. River life is life in isolation. To aquatic animals river life has the same limitations that island life has to the animals of the land. The oceanic islands are behind the continents in the process of evolution. In like manner the rivers are ages behind the seas.

Therefore the influences which serve as a whole to intensify fish life, and tend to rid the fish of every character or structure it can not "use in its business," are most effective along the shores of the tropics. One phase of this is the reduction in numbers of vertebræ, or, more accurately, the increase of stress on each individual bone.

Another phase is the process of *cephalization*, the process by which the head becomes emphasized and the shoulder bones and other structures become connected with it or subordinated to it. Still another is the reduction and change of the swim-bladder and its utter loss of the function of lung or breathing organ which it occupied in the ganoid ancestors of modern fishes.

Conversely, as these changes are still in operation, we should find that in cold waters, deep waters, dark waters, fresh waters,

inclosed waters, and in the waters of past geological epochs, the process would be less completed, the numbers of vertebræ would be larger, while the individual vertebræ remain smaller, less complete, and less perfectly ossified.

This, in a general way, is precisely what we do find in examining the skeletons of a large variety of fishes.

The life of the tropics, so far as fishes are concerned, offers many analogies to the life of cities, viewed from the standpoint of human development. In the cities in general, the conditions of individual existence for the man are most easy, but there also competition of life is most severe. The struggle for existence is not a struggle with the forces and conditions of Nature. It is not a struggle with wild beasts, unbroken forests, or stubborn soil, but a competition between man and man for the opportunity of living.

It is in the city where the influences which tend to modernization and concentration of the characters of the species go on most rapidly. It is adaptation or death to each individual in the city: every quality not directly useful tends to become lost or atrophied.

Conversely, it is in the "backwoods," the region farthest from human conflicts, where primitive customs, antiquated peculiarities, and useless traits are longest and most persistently retained. The life of the "backwoods" may be not less active or vigorous, but it will lack specialization. It is from the unused possibilities of the "backwoods" that the progress of the future comes. The high specialization of favored regions unfits its subjects for life under changed conditions. The loss of muscular power is often one of the results of skeletal specialization.

The coral reef is the metropolis of the fish. The deep sea, the arctic sea, and the isolated rivers—these are the ichthyological backwoods.

An exception to the general rule in regard to the numbers of vertebræ is found in the case of the eel. Eels inhabit nearly all seas, and everywhere they have many vertebræ. The eels of the tropics are at once more specialized and more degraded. They are better eels than those of northern regions, but, as the eel is a degraded type, they have gone further in the loss of structures in which this degeneration consists.

It is not well to push this analogy too far, but perhaps we can find in the comparison of the tropics and the cities some suggestion as to the development of the eel.

In the city there is always a class which follows in no degree the general line of development. Its members are specialized in a wholly different way. By this means they take to themselves a field which others have neglected, making up in low cunning what they lack in humanity or intelligence.

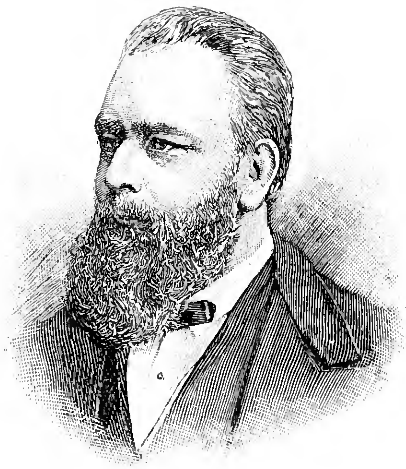
Thus, among the fishes, we have in the regions of closest competition this degenerate and non-fishlike type, lurking in holes among the rocks, or creeping in the sand, thieves and scavengers among fishes. The eels thus fill a place otherwise left unfilled. In their way they are perfectly adapted to the lives they lead. A multiplicity of vertebral joints is useless to the typical fish, but to the eel, strength and suppleness are everything. No armature of fin or scale or bone is so desirable as its power of escaping through the smallest opening.

DEATH OF PROFESSOR BILLROTH.

PROF. CHRISTIAN THEODOR ALBERT BILLROTH, one of the most eminent surgeons of the century, died at the Austrian winter resort Abbazia, on the Adriatic, February 6, 1894, in the sixty-fifth year of his age. He was born at Bergen, on the island of Rügen, the son of a Swedish Lutheran pastor, April 26, 1829; began the study of medicine in 1848 at Greifswald, in Pomerania, and, having continued his course at Göttingen and Berlin, was graduated in medicine from the latter university in 1852. He then traveled, after the manner of German professional students, visiting the schools of Paris and Vienna; served for several years as an assistant in the clinic of Prof. von Langenbeck, in Berlin; qualified as *Privat Docent* in the University of Berlin in 1856; became Professor of Surgery at Zurich in 1858, and in 1867 at Vienna, where he spent the rest of his professional life. He was made a member of the Austrian Chamber of Peers in 1887.

The beginning of his career as a professor in the University of Zurich was very modest. He had only ten pupils during his first semester, and his private practice, he was accustomed to say, was not enough "to pay for his morning cup of coffee." His reputation, however, quickly grew; students flocked to his lectures; and with the co-operation of eminent colleagues, notably Griesinger, the British Medical Journal says, he in a few years raised the Medical Faculty of Zurich to a prominent place among German-speaking schools. His clinic in Vienna, the same journal observes, has been for more than twenty six years "a kind of surgical Mecca to which scientific pilgrims from all parts of the world have resorted in constantly increasing numbers. . . . Here his operative triumphs were won. He excised the larynx for cancer in 1868; performed resection of the œsophagus; and first resected the stomach in 1881 for removing cancer of the pylorus. During the Franco-German War of 1870–'71 he served in the mili-

tary hospitals at Mannheim and Weissenburg, and obtained there so close and realizing views of the horrors of war that he was afterward one of the most earnest and persistent advocates of peace. His experience there also bore fruit in an address which he delivered in December, 1891, on the care of the wounded in war, which led to a large appropriation by the Austrian Chambers for the provision of adequate means of succor for the wounded; and great improvements have been made in the transport of the wounded and in ambulance service generally. He was the founder of the Rudolphin-Haus, a school for hospital nurses, and projected a model hospital in Vienna, made up of separate and isolated dwellings.



Prof. Billroth's literary activity is pronounced immense. He was the author of about one hundred and forty books and papers. Among the more important of them are the Deutsche Chirurgie, which he prepared in connection with Lücke; the Text-Book of General and Special Surgery of Billroth and Von Pitha, published in 1882, to which he contributed the section on Scrofulosis and Tuberculosis, Injuries and Diseases of the Breast, Instruments and Operations, Frostbites, etc.; Nursing at Home and in Hospital; General Surgical Pathology and Therapeutics, which has been translated into nine languages; Clinical Surgery, or Reports of Surgical Practice between the Years 1860 and 1876, which was translated for the Sydenham Society, London, in 1881; Surgical Letters from Mannheim and Weissenburg, recording the results of his experiences and observations in military surgery; and his papers on the management of gunshot wounds and on the transportation of the wounded.

As an operator, Sir William MacCormac says of him that "his knowledge and boldness were only equaled by his brilliant execution and skill; and what he did and his reasons for doing it were explained to his overflowing class with a rare talent for exposition." Mr. Clinton Dent, the translator of his Clinical Surgery, credits him with uniting the two qualities of ingenuity and boldness in devising operations with the manipulative skill, decision, and tact required to carry them out. "Yet it was always the guiding intellect rather than the manual dexterity which

impressed itself on the spectator. Truth to say, in actual performance of an important operation Billroth showed no marked superiority over his fellow-surgeons. He avoided any show of brilliancy or flourish, went steadily to work, erred, if at all, on the side of slowness, and was neither more nor less discomposed by any complication or untoward event than any one else. The finish of his operative work was rather the result of his immense experience than of any remarkable aptitude. . . . From first to last he was never a specialist, and his operative experience was singularly varied."

Dr. A. Wölfler, of Gratz, one of his most famous pupils, thinks that the chief power of his fame was not so much in his actual inventions in surgery as in the larger and more general ideas in medicine and surgery which he suggested. In the days when bacteriology was still groping in the dark—twenty years ago—he made successful investigations of a bacterium of wounds which he called streptococcus. In another direction he established and gave effect to general principles in nursing. His highest aim was to look out for the well-being and care of sufferers. Only in his later years did he busy himself with biological questions, and then pursued them with indefatigable ardor and persistence. His works are the classical text-books in Germany.

Prof. Billroth's earliest studies were in music, to which he was devotedly attached, and he retained a strong love for the art and its apostles. He was an excellent performer on the pianoforte and violin, and maintained a close friendship with Johann Strauss, Wagner, and Brahms.

THE GREAT BLUESTONE INDUSTRY.

By HENRY BALCH INGRAM.

HOWEVER unhappy New York city may be in the matter of pavements between curbs, there is one fact apparent to the most casual observer, and that is that New York has the finest and best sidewalk pavements of any city in the universe. This is due to the fact that the sidewalks are largely paved with huge flat slabs of a natural product known in the commercial marts of New York as North or Hudson River bluestone. These slabs, which form smooth and dry platforms for the use of pedestrians, come from the quarries much in the same shape as they are laid upon the walks of nearly all of the Atlantic coast and many of the inland cities.

North River bluestone is a fine-grained compact sandstone, extremely hard and wearing upon a tool, and is made up of microscopic crystals of the sharpest sand. It abounds in inexhaustible

quantities in a belt of country reaching from the Helderberg Mountains in Albany County, in this State, diagonally across the southeastern portion of the State and into Pike and Wayne Counties in Pennsylvania. The bluestone belt varies in width, being in the shape of a scalene or elongated obtuse triangle, no two sides of which are equal. In Albany County, at Reidsville and Dormansville, and Greene County, composing the northern extremity of the belt, the territory producing good marketable stone is narrow, being confined to the foothills of the eastern watershed of the Catskills and the southern slope of the Helderbergs. The stone quarried here is gray in color, with frequent tinges of

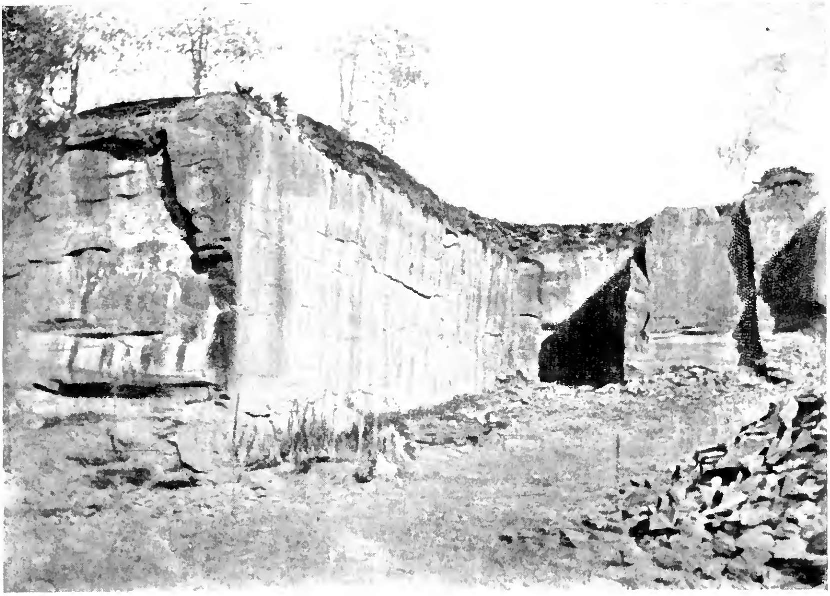


Fig. 1.—Bluestone Quarry at West Hurley, N. Y.

greenish and light-red and brown streaks, caused by the presence of calcite and ferric oxides. This stone is not regarded with favor by dealers, and brings a much lower price than the dark-blue product quarried farther down the river. The industry is also a vanishing one here, for the top matter to be removed in the quarries has become so heavy as the strata dip into the hills that few quarries pay to work at the present price paid for flagging stone. Many of the best-paying quarries of other days have been abandoned, and in consequence the ports of New Baltimore, Coxsackie, Athens, and Malden, particularly the last, have declined very much in importance since the shipments of stone have fallen off.

The bluestone belt follows the Hudson River until the town

of Saugerties, in Ulster County, is reached, when it takes a westward drift, being interrupted on the east by the older limestone formations, and on the north by the quartzose and conglomerate or pudding-stone formations of the Catskills, the latter of which undoubtedly rests on a foundation of bluestone, as it again makes its appearance on the westward side of the range. In the town of Saugerties the gray color of the stone disappears, and the formation takes on the deep-blue tinge whence it gets its name. Here also the belt begins to widen, and when the broad plateau at the foot of the Catskills, covered by the adjoining towns of Kings-

Fig. 2.—An Ulster County Monolith. Size, twenty by twenty-four feet; nine inches thick.

ton, Woodstock, Olive, Marbletown, Hurley, and Shandaken, is reached, the quarries are distributed over a range of country at least fifty miles broad. Here the stone varies but little in color, touching only the shades from medium to dark blue. The presence of ferric oxides is found in all the quarries, but only in the seams on the surface of the slabs, which have a rusty color from the oxidation. The stone produced in Ulster County has always commanded the largest prices, it being the best quality produced in the entire belt.

Leaving Ulster County, the bluestone belt crosses the Catskills, takes in a corner of Delaware and Orange Counties, and then

crosses Sullivan County until the Delaware River is reached, where quarrying is carried on all the way from Port Jervis to Narrowsburg on both sides of the river. Very little quarrying is done through the mountainous districts, although many quarries have been opened with a fair profit in Delaware County along the line of the Ulster and Delaware Railroad. The stone produced here, as well as along the Delaware River, is of a deep-red color, contains large quantities of ferruginous matter, is of uneven texture, requiring more cutting, and is much inferior to the stone quarried in Ulster County.

The history of the discovery and first attempt to quarry bluestone for the market is shrouded in uncertainty. It is known,

FIG. 3.—QUARRYMAN'S HOME WITH RUBBISH BANKS IN REAR, WEST HURLEY, N. Y.

however, that a man named Moray opened a quarry at what has since been called Moray Hill, near Kingston, as early as 1826. His son, the late Daniel Moray, of Kingston, said that his father was the first person to put bluestone as a product on the market, drawing the stone to Kingston with an ox team and selling it for window-sills and lintels. Philip Van de Bogart Lockwood was the most prominent producer of bluestone for many years after this, hauling the quarried product to the docks at Kingston Point, where it was loaded on sailing vessels and taken to the New York market. Later on, Abijah Smith built a dock and bought stone at Wilbur, which he shipped to New York, and in the early fifties the industry became so important that a plank road, eleven miles in length, was built on the Ulster and Delaware turnpike through

the quarrying country, for the better trucking of stone to the docks at Wilbur.

Some of the quarries have been veritable gold mines. One in particular, known as the great Lawson Quarry, at West Hurley, is said to have produced over four million dollars' worth of flag and other classes of bluestone. This quarry was worked by Lucius Lawson, now of Chattanooga, Tenn., for fully thirty years, and in it nearly two thirds of a village of three hundred people earned their living. The great quarry has now been abandoned, as the top has got so heavy that it does not pay to remove it to get at the good stone. In consequence of its abandonment, the village of West Hurley has dwindled to less than one third its former size, and is rapidly becoming a deserted village. Hundreds of other quarries have been abandoned for similar reasons, yet the whole bluestone district of Ulster County is thickly dotted with new quarries, which are opened as soon as the old ones are abandoned.

In working the quarries there is a great difference in the thickness of the slabs taken out. The formation exists in perpendicular blocks of different surface dimensions which are formed of flat plates piled up like cardboard. The top of worthless stone and earth is first removed by blasting with powder, after which wedges are driven in the natural seams which separate the plates, lifting them up, after which they are hoisted out with derricks. In working a block the slabs may run to several thicknesses, varying from two to ten inches. The thin slabs are then cut up into what is known as Corporation four and five foot flag and smaller sizes, while the heavier blocks are preserved intact for such huge platforms as we see reaching from building to curb line on the sidewalks of New York. Many of the blocks worked are so small in surface area that they are unfit for flagging, and are consequently worked up in coping, pillar caps, window and door sills and lintels, building and bridge stone for tramways. Other blocks are found suitable for curb and gutter alone, while some quarries furnish slabs so small and thin that they are used only for floor tiling, or for the facing of brick walls. Again, some of the slabs, or more properly platforms, taken from the quarries are from twenty to thirty feet square, ten inches thick, and weigh over twenty tons. Owing to the difficulty in handling and the danger of breakage during transportation, these platforms are seldom taken to tide water, but are broken up at the quarries into more convenient sizes for handling. Sometimes, however, monoliths of tremendous size and weight have been transported to the docks at Wilbur, the one shown in the illustration being twenty by twenty-four feet in surface area, nine inches thick, without a flaw, and weighing several hundredweight over twenty

tons. It was quarried at the Sawkill, in the town of Kingston, and is said to be the largest stone ever brought to tide water. It took eight horses to haul this monster to the docks over a stone tramway, and it is alleged that the side of a tollgate had to be taken down to allow the stone to pass through. In quarrying bluestone much stone that is practically worthless is met with. Sometimes what looks at first glance like a fine, straight-seamed block will be uncovered, when, at the first attempt to work it, it will break up into small pieces like a pile of brick. These blocks are known to quarrymen as cat faces. This formation exists in small blocks between all good working blocks, as well as sometimes in the

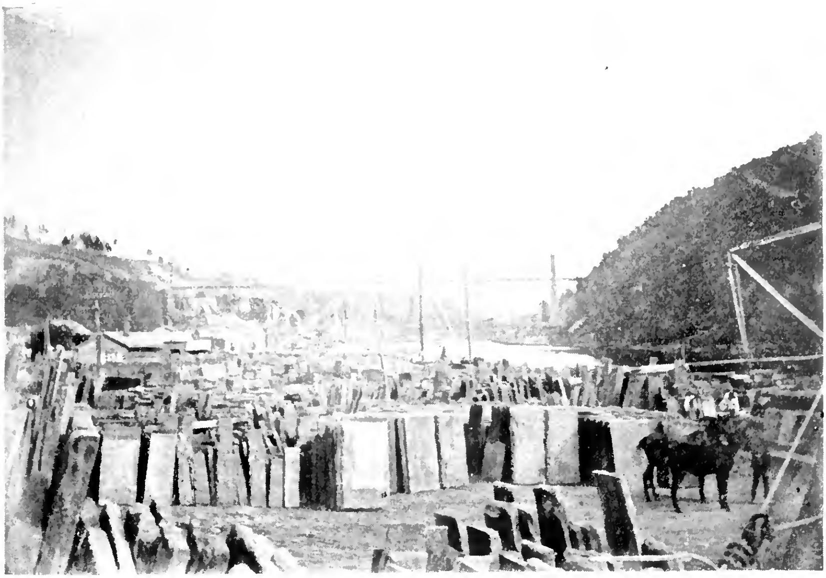


FIG. 4.—SHIPPING DOCK ON RONDOUT CREEK AT KINGSTON, N. Y.

larger ones. Cat faces are worked up into blocks for street paving, many having been used in the Hudson River cities, where they are set so the wear cuts across the grain, and have been found to wear superior to granite block, as they never become slippery, and furnish always a sure footing for horses. The worthless stone of the quarries, called rubbage, is hauled to the dumps, where immense mountains of broken stone, often one hundred feet in height and several acres in extent, have been built up.

The quarrying of bluestone and its allied industries furnish employment at good wages to a large number of people. It is estimated that throughout the entire bluestone country—reaching from Albany County, New York, to the Pennsylvania region on the Delaware River—at least twenty thousand people get all or a

portion of their support from the bluestone industry, while in the larger cities outside the bluestone belt hundreds of stonecutters are employed in dressing the stone. The wages run from a dollar and a quarter a day for common laborers to three dollars and a half a day for stonecutters, blacksmiths, tool makers, expert quarrymen, and other skilled labor. It would be hard to give a correct estimate as to the exact number of people who profit by the bluestone industry, as its influence is felt in all branches of mercantile trade, in lines of both water and land transportation, and, in fact, every industry throughout the district where the stone is found. To paralyze the bluestone traffic would mean to paralyze all branches of trade throughout that country.

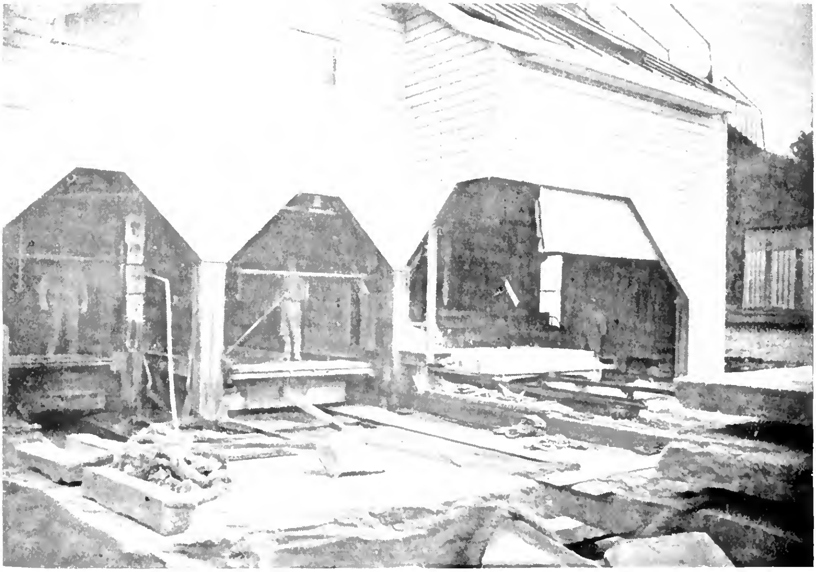


Fig. 5.—Bluestone Sawing and Planing Mills at Kingston, N. Y.

The bluestone trade amounts to nearly three million dollars annually, two thirds of which is paid out in wages.

The manner of working bluestone after it leaves the quarries is worthy of notice. Before it is taken to the docks the stone receives only a superficial dressing. At the docks it is piled up, and such as is needed to fill immediate orders is sent to the cutting mills. Here the large slabs are laid on huge bed planers and planed smooth as a board. Others are sent to the saws, which consist of a gang of thin strips of plate iron, running horizontally over the surface of the stone. Under the edges of the saws, which are toothless, is kept a supply of wet sand very sharp in grain. The constant grinding of the saws in the sand soon cuts into the stone and rends it into slabs or bars of the required size. Other stone

which is required to have a perfectly smooth surface is placed on huge revolving platforms of cast iron, the surface of which is kept covered with a thin coating of wet sand. The platform, revolving at high speed under the stone, soon rubs it smooth as polished metal—without the polish, however, as bluestone is not susceptible of polish. Other stone is dressed by hand by the stonecutters, who tool it with chisels and axes into different shapes. It is also turned in lathes in the shape of hitching posts, columns, and other forms, while it is susceptible of the most intricate carving, and is used at present in many classes of sculptured work for the ornamenting of buildings. Its extreme hardness makes it proof against all atmospheric changes, and it will neither shell like brownstone nor crumble like marble under the action of frost. It disintegrates and explodes, however, with terrific force under the action of intense heat.

The bluestone formation of New York State lying in Ulster County belongs to the Hamilton period, while that quarried in the other counties mentioned belongs to the Catskill group of rocks of the Upper Devonian age. As far as the writer has been able to learn, minerals are never found in the bluestone deposits, except in the form of oxides. Ignorant prospectors have at times reported the discovery of anthracite coal, which, however, has always proved to be a worthless deposit of organic slate, which in some localities abounds in considerable quantities. It is improbable that coal will ever be found in this region, as the stone formations that lie nearest the surface are those which underlie the coal measures of the entire country.

LADY MARY WORTLEY MONTAGU AND MODERN BACTERIOLOGY.

By Mrs. H. M. PLUNKETT.

IN all the history of modern scientific progress there is no more beautiful instance of the way in which the torch of knowledge is passed from hand to hand as generation succeeds generation, each holder adding his increment of light to the flame, than that to be seen in the interlinking of the work of Lady Mary Wortley Montagu and Edward Jenner with that of Pasteur and Lister and Koch, and the multitude of illustrious seekers now striving to reveal to us the whole world of man's microscopical friends and enemies. It is to be noted that in each individual case the mind that was to aid in setting forward the hand on the dial of progress was specially gifted for its work, so that when the new truth was presented to it, it was like the seed that fell on

good ground and brought forth fruit a hundredfold; while the knowledge of the same facts—always existent—had, outside of these illuminated intelligences, fallen on the stoniest kind of soil.

The relation of the beautiful and brilliant and witty Lady Montagu to one of the most beneficent applications of knowledge to the abatement and mitigation of human suffering, is at the present time very inadequately understood. Even in this day of boasted intelligence nine out of ten among persons who consider themselves well informed will say, "Yes, I know Lady Mary Wortley Montagu was the woman who introduced vaccination into England," whereas it was inoculation for smallpox that she had introduced. This produced a mild form of the disease, perfectly protective, and left no marks. Others had observed this Oriental practice, and had brought the knowledge back to England before her time, and here and there a venturesome individual had tried the experiment, but it was generally done in secret, being looked upon as akin to suicide. It was Lady Mary's intelligent enthusiasm that brought it into repute; she explained the conditions necessary to success, and set the example of having all belonging to her subjected to it. Her only brother had died of smallpox, and she had had it severely; it disfigured her to the extent of destroying a fine pair of eyebrows, resulting in imparting a fierce and disagreeable expression to her eyes, in spite of which she had won the heart and hand of an accomplished gentleman. Remember, this was in the first quarter of the last century, when communication between distant lands was infrequent, and women's books were almost unknown.

Her husband had been appointed in 1716 ambassador to the Ottoman court, and she had accompanied him, being then twenty-six years old. They made the journey overland through Germany, Austria, Bohemia, and Bulgaria, being the first Christians that had passed over the route since the time of the Greek emperors. It occupied more than four months, and, although hospitably entertained by the sovereigns in the large cities, as the representatives of their government, there were long reaches of country where they were obliged to use the beds and provisions that they carried along with them. She wrote back lively and brilliant descriptions of Eastern life in letters that to this day are "mighty interesting reading," the arrival of each being an event in the court coterie of her friends; they were passed from hand to hand, commented on, and enjoyed with a relish that the surfeited readers of to-day can not know, and one of them was appointed to exercise a potent influence on the destiny of millions of the human race, for it was eventually to lead up to the discoveries of Jenner. They were not printed till after her death, in 1762. The one which at last led to the establishment and popularization of inoc-

ulation for smallpox was written from Adrianople in 1717 to her friend Miss Sarah Chiswell. The passage relating to inoculation is here given entire: "Apropos of distempers, I am going to tell you of a thing that I am sure will make you wish yourself here. The smallpox, so general and so fatal among us, is entirely harmless here by the invention of *ingrafting*, which is the term they give it here. There is a set of old women who make it their business to perform the operation in the month of September, when the great heat is abated. People send to one another to know if any of their family has a mind to have the smallpox. They make parties for the purpose, and when they are met—commonly fifteen or sixteen together—the old woman comes with a nutshell full of the matter of the *best sort of smallpox*, and asks what vein you will please to have opened. She immediately rips open the one that you offer to her with a large needle, which gives you no more pain than a common scratch, and puts into the vein as much venom as can lie upon the head of her needle, and after, binds up the little wound with a hollow bit of shell, and in this manner opens four or five veins. The Grecians have commonly the superstition of opening one in the middle of the forehead and in each arm and on the breast, to make the sign of the cross; but this has a very ill effect, all the wounds leaving little scars, and is not done by those that are not superstitious, who choose to have them in the legs or in that part of the arm that is concealed. The children or young patients play together all the rest of the day, and are in perfect health till the eighth; then the fever begins to seize them, and they keep their beds two days, very seldom three. *They have very rarely above twenty or thirty in their faces, which never mark;* and in eight days' time are as well as before their illness. Where they are wounded there remain running sores during their distemper, which I doubt not is a great relief of it. Every year thousands undergo this operation, and the French ambassador says that they take the smallpox here by way of diversion, as they take the waters in other countries. There is no example of any one has died in it, and you may well believe I am very well satisfied of the safety of the experiment since I intend to try it on my dear little son. I am patriot enough to take pains to bring this useful invention into fashion in England, and I should not fail to write to some of the doctors very particularly about it if I knew any of them that I thought had virtue enough to destroy such a considerable part of their revenue for the good of mankind. But that distemper is too beneficial to them not to expose to all their resentment the hardy wight that should undertake to put an end to it. Perhaps if I live to return I shall have the courage to war with them. Upon this occasion admire the heroism in the heart of your friend."

Macaulay has this eloquent passage on this disease when describing the miseries of the old times: "Smallpox was always present, filling the churchyards with corpses, leaving in those whose lives it spared the hideous traces of its power, turning the babe into a changeling at which the mother shuddered, and making the eyes and cheeks of the betrothed maiden objects of horror to her lover." No wonder that the Lady Mary underscores the part which says it leaves no mark—a womanly touch for which we love her.

She had Mr. Maitland, surgeon to the embassy, procure variolous matter from a suitable subject, and a very experienced old Greek woman was employed to insert it; she inoculated one arm and Maitland the other; the disease ensued in due course, with the production of about a hundred pustules. This was the first time that the Byzantine method was employed on an English subject.

Mr. Montagu was attending to his ambassadorial duties at Belgrade at the time, and she wrote to him on March 23, 1718: "The boy was ingrafted last Tuesday, and is at this time singing and playing, very impatient for his supper; I pray God my next may give as good an account of him. I can not ingraft the girl; her nurse has not had the smallpox." Persons who have smallpox by inoculation impart it to others just as if they had acquired the disease in the natural manner, but we may be quite sure that the little lady was submitted to the operation that would preserve her beauty as soon as possible after she was weaned. Her husband being politically promoted, they returned to England after having lived in Turkey but little more than a year, and Dr. Maitland at once endeavored to establish the practice in London, being enthusiastically seconded and supported by her. Not till 1781, as its expediency had been agitated by scientific men, was an experiment sanctioned by the College of Physicians and allowed by Government. Five persons condemned to death willingly encountered the danger, with the hope of life. Upon four of them the eruption appeared on the seventh day; the fifth was a woman on whom it never appeared, but she confessed that she had had the disease when an infant. Lady Mary strove so earnestly to introduce the practice among mothers of her own rank in life that we learn from her letters that much of her time was given up to consultations and superintending the success of her plans. Steele, in his Plain-Dealer of July 3, 1724, wrote of her: "It is an obserxation of some historian that England has owed to women the greatest blessings she has been distinguished by. In the case we are now upon this reflection will stand justified. We are indebted to the reason and courage of a lady for the introduction of *this art*, which gains such strength in its progress that the mem-

ory of its illustrious foundress will be rendered sacred by it to future ages. . . . She consecrated its first effects on the persons of her own fine children; and has already received this glory from it that the influence of her example has reached as high as the blood royal. It is a godlike delight she must be conscious of when she considers the many thousands of lives that will be saved every year after the general establishment of the practice—a good so lasting and so vast that none of those wide endowments and deep foundations of public charity that have made most noise in the world deserve at all to be compared with it." To understand how great the deliverance was, it should be known that then it killed one in seven of all that were born; it caused about one third of all the blindness in those pitiable victims, and it disfigured multitudes frightfully. Mrs. Croasdale, an English lady born early in this century, mentions in a recent book of reminiscences that in her childhood so many were "pitted" that a person with a smooth face was notable.

Notwithstanding this eulogy from a highly intelligent source, it is pretty certain that, like all those persons who are overmasteringly possessed with one idea, she was considered an unreasonable "crank." The very friend to whom she wrote the minute description of the process died of smallpox; and the Lady Mary's sister, Lady Mar, had that most precious of English aristocratic possessions—an only son. She offered to inoculate him, and promised to take him into her own house and care for him personally till he should be recovered; but the sister failed to be convinced, and the boy died in childhood of the disease.

People still remained so skeptical that Lady Mary used to take her little daughter into houses where people had been inoculated, and whose convalescence she was superintending, to prove her own immovable conviction of it as a protective measure.

At one time such unreasonable prejudices were excited that clergymen and physicians became violent anti-inoculators. Pamphlets appeared in which it was described as the outcome of "atheism, quackery, and avarice"; it was denounced from the pulpit as "an impious interference with the just and inscrutable visitations of God"; and Dr. Wagstaffe, of St. Bartholomew's Hospital, said that "posterity would marvel that a practice employed by a few ignorant women, among an illiterate and unthinking people, should have so suddenly been adopted by one of the politest nations in the world." That this was a narrow and unmerited piece of severity is shown by the facts that these "unthinking" people had discovered that there is a difference in the features of the disease in different cases—hæmorrhagic, confluent, discrete, etc.; that those artificially produced follow closely the character of the cases from which they are planted, each yielding "seed

after his kind"; that it is important to have the system in a healthy condition, which they tested by making a slight wound, and if it healed kindly and normally, they concluded that the inoculation would come out all right; they chose the most favorable month of the year, and they isolated, not individuals, but parties, for, as the Turks were not a reading people, we can imagine that social aggregations saved them from the *ennui* of sickness and convalescence. After the practice was introduced among the "politest peoples," some serious disasters came from neglecting the precautions that had been found absolutely essential to oriental success. As to the "sudden" adoption: in spite of her enthusiastic advocacy, it was not till fifty years after Lady Mary's children were inoculated that the practice became established in her native land, and then not till the Princess of Wales, having had some charity children operated on to satisfy herself of its safety, caused her sons to be inoculated, thus giving that royal sanction so needful there to make a thing "go." Having thus acquired the royal stamp, the College of Physicians formally indorsed it. No less than eighteen individuals had died in Lord Petrie's family alone, in the twenty-seven years preceding 1762, and among the royal families of Europe fifteen persons had perished within the compass of a single year.

The Lady Mary resided in Italy for twenty-two of the later years of her life, returning to die of cancer in 1762, aged seventy-three. In the cathedral at Litchfield a cenotaph is erected to her memory bearing this inscription:

"SACRED TO THE MEMORY OF
THE RIGHT HONORABLE
LADY MARY WORTLEY MONTAGU,
WHO HAPPILY INTRODUCED FROM TURKEY
INTO THIS COUNTRY
THE SALUTARY ART
OF INOCULATING THE SMALLPOX.
CONVINCED OF ITS EFFICACY
SHE FIRST TRIED IT WITH SUCCESS
ON HER OWN CHILDREN
AND THEN RECOMMENDED THE PRACTICE OF IT
TO HER FELLOW-CITIZENS.
THUS BY HER EXAMPLE AND ADVICE
WE HAVE SOFTENED THE VIRULENCE
AND ESCAPED THE DANGER OF THIS MALIGNANT DISEASE.
TO PERPETUATE THE MEMORY OF SUCH BENEVOLENCE
AND TO EXPRESS HER GRATITUDE
FOR THE BENEFIT SHE HERSELF RECEIVED
FROM THIS ALLEVIATING ART,
THIS MONUMENT IS ERECTED BY
HENRIETTA INGE—
RELICT OF THEODORE WILLIAM INGE, ESQ.,
AND DAUGHTER OF SIR JOHN WROTTELSEY, BART.,
IN THE YEAR OF OUR LORD 1789.

The monument itself is a mural marble, representing a female figure of Beauty weeping over the ashes of her preserver, supposed to be inclosed in the urn inscribed with M. W. M. intertwined in

Lady Mary's cipher. In the literary remains of the time, the fact that she had preserved the *beauty* of her countrywomen is mentioned ten times to one of the preservation of life.

Lady Mary's thoroughly intelligent account of the process shows that in her case the new idea had fallen into a hospitable and enlightened mind, and although she did not live to see the fruition of her efforts in the immense amelioration of the condition of her countrymen that took place later, there was wrapped up in the process she had naturalized the germ of a mighty fact of biology destined to spring up and bear a myriad of those leaves that are "for the healing of the nations." When the value of the operation was thoroughly appreciated there came upon the scene some enterprising doctors who established what they called "inoculation houses"—we should say now smallpox sanitariums—for isolation was needed to preserve the community, as the disease communicated itself as surely through voluntary sufferers as when it had been taken unwittingly. Here the candidate was put through a course of medication that to-day seems nothing less than ferocious; and one doctor—Dimsdale—rendered himself so conspicuous as to be knighted, and the Empress of Russia sent for him to inoculate herself and her son Paul. The bold experiment was first tried on two young gentlemen of the cadet corps, and afterward, a second experiment was made on four more cadets, before royalty ventured. Then the exalted candidates passed safely through it, and Dimsdale says, "the Empress and the Grand Duke were pleased to permit several persons to be inoculated from them, and by that condescension the prejudice which has reigned among the inferior ranks of people that the party would suffer from whom the infectious matter was taken was most effectually destroyed." Dimsdale was made Baron of the Russian Empire and physician to her Imperial Majesty, and awarded ten thousand pounds in addition to an annuity of five hundred pounds. As up to this time every seventh child born in the Russian Empire had died of smallpox, the royal conduct is to be commended.

A careful sifting of all the methods and recorded experiences of all the inoculators shows that the essential vital kernel of the process grazed closely on Pasteur's "attenuated virus," and that all their "cooling" and "dieting" and "strengthening" sank into insignificance beside the one dominating point of using a *benign* virus, if such a contradiction in terms is allowable. Much valuable knowledge in reference to inoculation was accumulated, and some brilliant foreshadowings of modern knowledge as to the way in which infection spreads were seen, but these discoveries were soon to be thrown into eclipse by those of Edward Jenner.

This great benefactor of humanity was born in Berkeley, in Gloucestershire, in 1749, and at the time of Lady Mary Montagu's

death was thirteen years old, but he already had evinced a strong taste for natural history—had begun an orderly and well-kept cabinet of new and original specimens, and had formed the valuable habit of recording in a note-book his observations on physical phenomena. His father had died when he was six years old, but he was reared with great care and tenderness by an elder brother, who, perceiving his strong natural bent, apprenticed him to a surgeon, with whom he diligently studied and worked till he was twenty-one, when he went to London to become the pupil of the celebrated John Hunter, in whose family he lived for two years. Hunter had a large private menagerie at Brompton, where he solved for himself some important questions in physiology. Jenner, filled with admiration at the large and unselfish way in which Hunter pursued knowledge for its own sake, formed a friendship for his great master that ceased only at Hunter's death, whose letters to Jenner are among the most interesting extant.

While yet a surgeon's apprentice, before he went to London, he had written in his note-book that he had heard a milkmaid say "she could not have the smallpox as she had had cow-pox"; and the Duchess of Cleveland, when taunted that she might lose her beauty, had replied, "I have no fear of that, for I have had a disease that will save me"; and he was familiar with the general tradition in the dairies of Gloucestershire that those who had contracted cow-pox from the cows would never have smallpox. The thought came to him, *Can this virus be inserted voluntarily in the human subject?* He mentioned his speculations on the subject, that was even then taking a firm hold on his mind and inexorably marking out his *rôle* in life, to Hunter, who listened with interest, thought they were "curious," but was too much absorbed by his own engrossing themes to more than repeat his famous instruction, "Don't think, but try." That the new idea in biological science that was to rescue millions from premature graves came to a trained intelligence is further shown by the fact that, while Hunter's pupil, Jenner had been employed to prepare and arrange the valuable zoölogical specimens brought back by Captain Cook's first expedition in 1771, and did the work so acceptably as to be invited to accompany the second expedition as naturalist—an honor which he refused, preferring to return to his country home and engage in the practice of his profession near the brother to whom he was devotedly attached; and those who believe in the "destiny that shapes our ends" will say, where he could study the mysteries of cow-pox in its native haunts. He soon had a large practice, and he formed a society of the medical men of his vicinity—they discussed medicine first and dined afterward—Jenner contributing his full share both of the solid work and the fun. Hunter wrote him, "I am very happy that some of you have wished to commu-

nicate your ideas to each other." On these occasions he would often bring forward his suspicions on the subject of the relations of small-pox and cow-pox—a theme that was taking commanding possession of his mind. His medical friends treated his ideas with indifference, or brought forward instances that militated against his theory; called him a "dreamer"—how often "Behold this dreamer cometh" greets advanced ideas!—and finally they began to consider him a bore, and threatened to expel him if he did not cease to trot out his hobby. Meantime, while not neglecting his practice, and while following up many lines of physiological and pathological investigation, he continued to collect all the facts and observations, and what other people thought counter facts, that had a bearing on the relation between cow-pox and small-pox; and in 1788 carried a drawing of the cow-pox, as seen on the hands of a milkmaid, to London, and showed it to Sir Everard Home, the President of the College of Surgeons, to convince him of the identity of the two diseases. Sir Everard condescended to assure him that "it was a curious and interesting subject."

Owing to the rarity of the disease in the dairies, or to its concealment, for which there was a strong motive, it was a long time before he found an opportunity of testing his theories by experiment. On the 14th of May, 1796, he took lymph from the hand of a dairymaid who had caught the disease in milking, and inserted it by two superficial incisions in the arms of James Phipps, a healthy boy about eight years old. He passed through the disease in a regular and satisfactory manner, but the most anxious time was yet to come; it was necessary to show that the boy was proof against the *contagium* of smallpox. In the following July this was settled, for variolous matter taken directly from the pustule was inserted by several incisions, but no disease followed. He wrote to the friend, Mr. Gardner, in whom he had always confided his hopes, "You will be gratified in hearing that I have at length accomplished what I have been so long waiting for: the passing of the *vaccine virus* from one human being to another by the ordinary mode of inoculation." After minutely detailing the process, he adds, "I shall now pursue my experiments with redoubled ardor." It was now twenty-five years since he had mentioned his "suspicions" to Hunter, a fact to be remembered when, afterward, he was rebuked by pompous arrogance in the person of Dr. Ingenhousz, for too hastily rushing into print, which he did not do till he had collected twenty-three cases, all of whom had passed through vaccination successfully, and had been tested subsequently by the inoculation of variolous virus and shown to be proof against it.

This was the high tide of happiness in Jenner's life—he was under a great degree of mental exaltation, although he maintained

his humility and disinterestedness. In writing of this period he says, "While the vaccine discovery was progressive, the joy I felt was at the prospect before me of being the instrument destined to take away from the world one of its greatest calamities."

What he really accomplished during those twenty-five years of preparation and waiting is, succinctly, as follows:

1. He perceived that some profound modification of the effects of the virus of smallpox occurred when it was introduced through a puncture in the skin, instead of finding its way to the system through the natural channels of the lungs and the stomach.

2. That cow-pox was really smallpox in cows,* but that the disease in passing through the tissues of that animal underwent a still greater modification, by which its period was lessened, and that it became non-contagious, unless a person brought in contact with it had some abrasion of the skin.

3. That persons who had accidentally acquired it from the cow did not give it to others while passing through it, and were henceforth secure from attacks of smallpox.

It was his putting of "this and that together" that made the great step forward: could this modified virus be inoculated successfully into the human system as smallpox had been; and, if so, would it protect against smallpox? James Phipps had furnished the triumphant answer, and his other twenty-two cases had confirmed its truth. He did not find a second opportunity for putting his hypothesis to the test till 1798; he then repeated his inoculations with the utmost care, and prepared his book for printing. Before giving his work to the press, he devoted the most solemn and conscientious care to it, reading it sentence by sentence to a few of his most intimate friends and asking for their unsparing criticism. Its title was, An Inquiry into the Causes and Effects of the Variolæ Vaccinæ (Cow-pox). These friends saw in it a great victory of the sagacity of man over one of the most fatal of diseases, and they urged him forward in his purpose of opening for the benefit of all "the stream of life and health he had been permitted to discover"; in their enthusiasm they said "he seemed to hold in his hand one of the gates of death, with power to close it." In addition to the great fact that constituted the vital kernel of his discovery, he had incidentally learned much besides. He was convinced that there were two similar-appearing diseases affecting cows that could be imparted to man, one of which he named "spurious," and which afforded no protection against smallpox. He also learned that there were rare cases where per-

* An opinion confirmed by an account of experiments published in *La Semaine Médicale*, December 31, 1890, made by Elternod, of Geneva; Haccius, the Director of the Vaccine Institute of Lancy; and of Dr. Fischer, Director of the Vaccine Institute at Carlsruhe in Germany

sons had had a second attack of smallpox, and that there were cases where people who had acquired what they thought cow-pox in the natural manner had been attacked by smallpox later. He set himself to study these anomalies, and became convinced that there is one "right," strictly limited time for taking the vaccine virus, and that matter taken later will produce a pustule and severe illness, but affords no protection. Also, he learned that there is a right and a wrong way in which to insert the virus—in short, that the operation is a nice exercise of medical art. He discovered that certain eruptive diseases occurring at the same time make the best virus inoperative, and he ascertained that there are many circumstances that rapidly destroy the vitality of the virus when not properly cared for. He left the fruits of all these observations embodied in a set of rules of procedure that nearly a century of experience and medical advance has not improved upon. Of course, he could not foresee the wonderful evolution in the methods of the production of the virus that now puts such a large and safe supply into the hands of the practitioner.

We, who tranquilly enjoy the fruits of the great deliverance from the horrible and universal plague of smallpox, see and know so little of it as not to be able to form any just conceptions of the monstrous proportions of the scourge when unchecked. The average death-rate from it throughout England was such that if applied to the present population it would give 70,000 per annum; in London alone before 1804 the annual deaths were 2,018 in a population of a million; in 1890, in a population of four millions there was just one death from smallpox. In the year 1886 there was not a death from it in Massachusetts.

Jenner went to London in April, 1798, intending to bring out his book and illustrate his doctrines on the spot. He was prepared with a pure and efficient virus that had been already tested, but to his surprise and chagrin, although he was known in the highest medical circles as a man worthy of undoubted credit and of thoroughly established scientific repute, he could not find one individual willing to submit to the operation. His pamphlet—a quarto of seventy pages—was published on June 21, 1798. Seldom has a book appeared fraught with greater consequences to mankind. When he went home he left some virus in the hands of a friend—Mr. Cline—who at the end of July inserted some of it by two punctures on the hip of a child who had hip disease, under the notion that the counter-irritation produced by it might cure the trouble. It made no difference with the original disease, but by a thorough inoculation afterward with smallpox virus the child was found proof against that disease.

When the book had had time to make its due impression, with its thoroughly wrought-out and carefully written-out series of

twenty-three cases, the most advanced minds among doctors at home, as well as in all the capitals of Europe, were hospitable to the discovery and perceived the immense benefits likely to flow from it. On the 27th of November, 1798, Jenner vaccinated two children of a Mr. Hicks with lymph taken from a farm at Stonehouse, this gentleman being the first private subject to allow the experiment on his children.

Lady Ducie was the first person of rank who gave tangible support to the practice by having her only child vaccinated. No better comment on the better day in which we live exists through the diffusion of knowledge by the newspaper press, daily recording the discoveries of scientists, than the audacious attempt made in London to supplant Jenner, which came near being successful, and during its progress beclouded his discovery and caused him great anxiety, notwithstanding which the story of the triumphant adoption of the practice in all the enlightened countries of the earth reads like a fairy tale. Monarchs honored him, decorations and gifts were showered upon him, and, in the height of his joy, there was not wanting the one black drop to keep him humble and sober, in the existence of a knot of anti-vaccinationists whose pestilent successors are not yet vanished from the face of the earth, though very recently towns in which their influence has ruled have been scourged with smallpox. At this juncture he wrote to his friend Gardner: "At present I have not the most distant doubt that *any person who has once felt the influence of perfect cow-pox matter would never be susceptible of smallpox*, but on the contrary, when the disease has been excited by the matter of cow-pox in an imperfect condition, the specific change of the constitution necessary to render the contagion of smallpox harmless is not produced; and in this point of view there is a close analogy between the propagation of the cow-pox and the smallpox. Therefore, I conceive that it would be prudent, until further inquiry has thrown every light on the subject that it is capable of receiving, that—like those who were the objects of my experiments—all should be subjected to the test of variolous matter who have been inoculated for smallpox."

Another circumstance of a different sort at times tried Jenner's accurate and scientific soul. He had vaccinated thousands gratuitously, and taught many persons to perform the operation correctly; clergymen and noblemen and women learned to perform the operation, strictly according to his instruction, and applied their knowledge on thousands of the people dependent upon them with perfect success; but doctors, wise in their own conceit, caused every now and again disaster, by not being careful enough about the exact "right time" to take the lymph in the arm-to-arm practice that had generally disseminated itself.

Still, he had the satisfaction of seeing compulsory vaccination established in many of the countries of Europe, and knew that it was making its way among enlightened peoples everywhere, before his death in 1823, which occurred in his native rural home, where he had returned after a short and distasteful residence in London. Ten days before his death he got a letter, on the back of which he wrote the following: "My opinion of vaccination is precisely as it was when I first promulgated the discovery. It is not in the least strengthened by any event that has happened, for it could gain no strength. It is not in the least weakened, for if the failures you speak of had not happened, the truth of my assertions respecting the coincidences which occasioned them could not have been made out."

In the seventy years since, evidence has accumulated as to the inestimable value of the original discovery; wide observations among thoroughly trained medical men have also demonstrated the value of revaccination—after maturity—of persons who had been vaccinated in infancy; but the most glorious result of all was to be the illumination of Pasteur's great scientific mind, as to the possibility of the production of a modified virus in other diseases than smallpox.

Modern science contains no more interesting chapter than the one which shows how that, after the achromatic compound microscope—magnifying close on to two thousand diameters—was put into the hands of scientists, step by step it was shown that what we call zymotic or "catching" diseases are caused by the living germs of parasitic plants entering the blood, and there multiplying and growing, deriving the needed sustenance from the blood itself. Pasteur caught the idea of a modified growth from Jenner's experiments, as he distinctly said in his original paper on anthrax, read before the French Academy. That it is within the power of man to modify plants outside the body, any one who has tasted a native astringent crab and a delicious Baldwin apple will believe, but it remained for a devotee of science for its own sake—like Pasteur—to observe and experiment and think till he achieved that "attenuated virus" which annually saves millions of animals in Europe from the ravages of anthrax, and multitudes of men from death by hydrophobia through the bites of wolves, dogs, and cats. The statistics of the Pasteur Institute of Paris show that in the five years from January 1, 1886, no less than nine thousand four hundred and thirty-three persons were treated, of whom fifty-eight died, or 0·61 per cent. The instrument of this merciful exemption was a modified—i. e., attenuated—virus.

With such results, such victories of the wit of man over Nature, while bacteriology is yet in its early infancy, it is no wonder that Pasteur predicts the time when "these diseases will be

made to disappear from the face of the earth"; and as a fine example of the way in which mind kindles mind, we will cite the way in which Pasteur's study of *pébrine* in silkworms, and his formulation of the germ theory of disease, put into Lister's hand the true key to the havoc of bacteria in wounds, and enabled him to lay the foundation of modern antiseptic surgery which annually saves its thousands from death.

He noted that when a man broke a rib he had no "surgical fever," but made a safe and rapid recovery, unless the bone had penetrated the lung, when he died of pneumonia; but that other surgical wounds behaved very differently—that some exterior substance got into them; and Pasteur's studies taught him what was the element of mischief, so that we are justified in drawing out a certified pedigree as follows:

It was Lady Mary's observation of the difference in its consequences whether that which she called "matter," but which we now know to be the infinitesimal seeds of microscopical plants, came into the human system unconsciously through the lungs and stomach, or whether it was deliberately inserted artificially, of course making its way through the lymph-channels, that led Jenner to ask himself whether the seeds of the disease as modified by passing through the tissues of the cow might not also be inserted artificially. Fifty years after his death Pasteur, inaugurated the science of "microscopical botany," and had convinced himself that all the contagious diseases are the result of parasitic growths, and in his original papers, read before the French Academy, says he was put upon thinking whether the Jennerian application of a modified, "attenuated," less virulent virus could not be made in other diseases by the success in vaccination, and like a true knight of science he did not rest till he had produced and used such a remedy, saving millions of animals annually from the ravages of anthrax and thousands of men from hydrophobia. Continental flocks and herds are now as regularly "inoculated" as our children are vaccinated, but the greatest result of all is Lister's establishment of what is known as antiseptic surgery. In the thousand laboratories where splendid work for humanity is to-day progressing a picture of the Lady Mary, as inspiring genius, ought to be hung up; and it certainly is pleasant to the wide-awake women of the last decade of this nineteenth century to find, as we follow the unbroken chain backward, its first link in the delicate hand of an intelligent and courageous woman who dared to confer a priceless benefit, at the risk of obloquy, in the first quarter of the last.

JOSEPH NEEF: A PESTALOZZIAN PIONEER.

By A. Carman.

THE Hon. George S. Boutwell, in the November number of The Popular Science Monthly, referred to a recent article by Prof. W. W. Aber on the Oswego State Normal School, in which is claimed for that school the credit of introducing into this country the Pestalozzian system of teaching. The Oswego School was founded in 1853, and Mr. Boutwell says that from about the year 1839 this "art of teaching was taught" in the Massachusetts State Normal Schools.

While the first schools for teachers of the Pestalozzian system may have been in Massachusetts, Pennsylvania may yet claim the credit of having the first Pestalozzian school for children in America. It was established in 1809 by Joseph Neef, at a spot then called the Falls of the Schuylkill, some four miles from the old city of Philadelphia, now part of Fairmount Park.

Francis Joseph Nicholas Neef was born in Soultz, Alsace, December 6, 1770. He was educated for the Roman Catholic priesthood, but at the age of twenty-one, when about to take orders, he gave up the idea of entering the Church, as not being at all suited to his tastes. He entered the French army under Napoleon, attaining high rank therein, and in the battle of Arcola was severely wounded in the head by a spent ounce ball, which he carried to the day of his death, a period of over fifty years. After leaving the army he became teacher of languages in Pestalozzi's celebrated school at Burgdorf, Switzerland, where he remained for some years, being then sent by Pestalozzi to Paris at the request of a philanthropic society whose attention and interest had been at tracted to the good work being done at Burgdorf.

During Neef's stay in Paris, Mr. William Maclure, an American patron of education, science, and philanthropy, visited Pestalozzi's school, which had by that time been moved to Yverdun. Mr. Maclure was so favorably impressed by the rational methods employed in this school that he conceived the generous idea of establishing a similar institution near Philadelphia, where he was then living. Pestalozzi recommended to him his former coadjutor, Joseph Neef, as a man thoroughly imbued with his principles and well fitted to introduce them into the Western world. Neef, when approached on the subject, hesitated, for, though master of eight languages, he was ignorant of the English. Persuaded, however, that he could soon overcome this difficulty, he came to America, and such was his success that within a year he published a work of one hundred and sixty-eight pages in the English language, with the following descriptive title: Sketch of a Plan and Method

of Education founded on an Analysis of the Human Faculties and Natural Reason, Suitable for the Offspring of a Free People, and for all Rational Beings. By Joseph Neef (formerly a Coadjutor of Pestalozzi, at his School near Berne, in Switzerland). Philadelphia, 1808.

This work is faultless as to grammatical construction, and was the first strictly pedagogical work published in the English language in this country. It would interest any modern teacher who has read the numerous pedagogical works of to-day to give this quaint little volume a careful perusal. There are now but half a dozen known copies in existence, one being in the State Library at Indianapolis. Another work, Method of Teaching Children to Read and Write, was published by him in 1813.

Neef had in the school established at the Falls of the Schuylkill about one hundred pupils, most of them boarders, who were taught physiology, botany, geology, natural history, languages, mathematics, and other branches, without the aid of a single text-book, a purely natural method being followed. "Neef's boys from the Falls," as they were known to Philadelphians, could, without exception, after being in the school for a short time, work mentally the most difficult examples in arithmetic, converse with equal ease in several languages, and many who were his pupils have said in after years that the amount of scientific information and practical knowledge gained while under Neef's care had always been of incalculable benefit to them.

In 1813 he removed to Village Green, in Delaware County, Pennsylvania. David Glasgow Farragut was one of his pupils at this place. From here the school was moved to Louisville at the earnest solicitation of several Kentucky patrons. In 1826, when Robert Owen, of New Lanark, Scotland, began his famous socialistic experiment at New Harmony, Indiana, Mr. Neef took charge of the educational department of his community. In 1828 the community ceased to exist, and Mr. Neef removed to Cincinnati, and later to Steubenville, Ohio, where he engaged in his last school. He died at New Harmony in 1853.

The following extract is taken from his book published in 1808: "The man of refined morality feels it to be his duty not only to be good, but also to inquire in what situation and through what means he may be able to produce the greatest sum of good to his fellow-creatures. It is my ambition and duty to become a useful member of society. The education of children and the rearing of vegetables are the only occupations for which I feel any aptitude. I have, therefore, seriously inquired in which of these two spheres I should produce the greatest advantage to the society of which I may become a member, whether by clearing and tilling some secluded spot of land, or by cultivating the

pretty bewildered field of education. After mature deliberation I became fully convinced that in the latter capacity my faculties will be more likely to be beneficial to my fellow-creatures. These are my reasons for appearing as a teacher, or rather educator."

Mr. Neef left no male descendants, but two married daughters are still living in this country.

KILN-DRYING HARD WOOD.

By O. S. WHITMORE.

AMONG the many changes that have taken place in the manufacture and handling of lumber, there is none more marked or interesting than in the method of preparing lumber for use by getting rid of its natural or acquired moisture. For a century and a half after sawed lumber came into use, none but natural means were used for drying it, preparatory to its consumption in the building and kindred arts. Even in comparatively modern times, when sash, doors, and blinds were made by hand, and flooring and ceiling were dressed and matched in the same manner, if a person concluded to build some time in the future, the stock for these purposes was often bought after being weather-dried as much as possible and stored away in barns, lofts, and garrets, where it was not seldom left for years.

There can be no denying that this stock made excellent work, though it became not infrequently discolored from want of a circulation of air, which fact became so well understood that when at last attempts were made to shorten the drying period by artificial means, they all embodied some attempt, more or less crude, to create a circulation, to the end that the air that had enveloped the lumber until it had absorbed a portion of the moisture should be thrown or forced out of the drying room or building.

The first attempts at artificial drying did not contemplate general stock or drying lumber for shipping, the first dry-houses being usually nothing more than a one-story frame structure built over a low cellar excavated in the side of a hill, with a slatted floor above and a latticed cupola on the roof. A brick or tile furnace or arch was built in the cellar, from which extended a number of sheet-iron pipes which, while conveying the smoke to the chimney, also acted as radiators. The furnaces were built so as to be stoked from the outside through an arch in the wall on the down-hill side. After the introduction of cast-iron stoves, they were often substituted for the brick or tile furnaces, and in some cases these in turn were superseded by wrought-iron cylinders like steam-boiler shells.

The material to be dried was stacked upon the slatted floor in loose piles, through which the heated air from below could circulate more or less freely. For years these dry-houses—they were not then dignified by the name of kilns—were only used in connection with certain manufactories for drying stock already cut up for tubs, pails, and other wooden ware; small boxes, chairs, and other furniture material; turned work and Yankee-notion stock in general; no regular lumber stock being subjected to the process.

Occasionally a little lumber for interior finish, where an extra fine job was desired, was run through the dry-house for a final drying, and later, after machine-made sash, doors, and blinds began to take the place of the old hand-made goods, being generally made from air-dried stock, they were sometimes put through the dry-house before being wedged and pinned.

These dry-houses contained such an element of fire risk that they were generally built in isolated positions as close to water as possible. Even then they were a constant menace to all surrounding property as well as to their own contents. Lumber, except in small pieces, dried in them was apt to be checked and warped or twisted more or less, and was not at all satisfactory save in the one feature of being free from moisture.

The fire risk at last became so great where the establishments requiring the dry-houses were situated in towns, and the restrictions of underwriters so onerous, that along in the fifties some crude attempts were made to substitute steam for the furnaces by conducting the exhaust from the engines running the works into the cellars.

It is not definitely known when or by whom the first attempts were made, but it is a fact that as early as 1855 the trial was made by a manufacturer in northern Massachusetts. But the experiment did not prove very satisfactory, for the reason that the steam had to be carried quite a long distance; the science of protecting steam pipes so as to prevent condensation was not as well understood as at the present day; the engine was none too large and the boiler capacity limited, and there was more or less back pressure.

But so certain were the experimenters that they were on the right road that they kept up the trials, though, from causes stated, making but little attempt to use the steam during the winter months. Success seemed near, when the panic of 1857 came on, and the house met with reverses that stopped all further experiments. Some additional attempts were made in the New England States during the next four years, but in a rather desultory way, when, the war of the rebellion coming on, the inventive genius of the country seems to have been turned in

other directions and the subject of drying lumber slept for some years.

A patent was granted to Hannah and Osgood, November 27, 1866, for "an improvement in the method of drying lumber," and other patents followed in rapid succession, a full history of which is shown by the records of the Patent Office. But it does not appear that any really successful kiln was built until the year 1875, when one was erected at Stillwater, Minn., and a little later one in Chicago, if the records are correct, for Pond and Soper, though Turner Brothers had one built about the same time. The dates as to when the first steam drier was put in successful operation are a little foggy, claims being made both for Stillwater, Minn., and St. Albans, Vt.

The question of the artificial drying of hard-wood lumber has assumed such importance that all, both manufacturers and dealers, must be interested in the subject. To air-dry hard-wood lumber by simple, natural means involves the loss of interest on immense sums of money invested in the lumber while it is awaiting the slow and not always satisfactory or sure process of Nature; while, on the other hand, it is a well-admitted fact that unscientific and hence unskillful drying by artificial means often involves a loss greater than the other.

The earliest attempts at the artificial drying of lumber made no difference in the matter of varieties of wood or quality of stock. All kinds and qualities were run in promiscuously, and all subjected to the same treatment. The only theory acted upon was that the lumber, being green or wet, must be dried in the shortest possible time. To effect this result it was only thought necessary to create as great a heat as possible within the limits of safety, and to raise it to the maximum degree in the very shortest time, the limit being often raised to a reckless height, not infrequently reaching the point of actual partial carbonization to an extent that killed the life of the lumber so treated. Often the kiln would be hastily opened for the removal of dry stock, while it was under full headway, with the heat up to the highest point, and green and often frozen lumber hurried in to receive at the very outset a blast of heat as near the point of combustion as it was possible to raise it with any degree of safety.

This, of course, has reference more particularly to the days of dry hot air and furnace heat, though the same was true of the earliest attempts at steam heating. Nothing was known or thought of the effect of thus subjecting lumber to a high temperature at the very first stage of the drying process, and nothing was known of the effect of high temperature upon different varieties of wood or the same variety under different conditions, whether entirely green, or partially or wholly air-dried. One

thing only was known—that heat would drive the moisture, whether natural or acquired, out of the lumber, if it was only applied hot enough and long enough.

The physiology of wood, or what is now known as timber physics, was poorly understood by any one, much less by the men who were making the experiments; for in general they were plain business men, with only ordinary business education, and with no pretensions to scientific knowledge.

Thus little or nothing was known of the chemistry of woods and absolutely nothing of the effect of heat upon the gums, juices, or fibers. But while these men were not up in the sciences, they possessed what perhaps in this instance stood them in as good stead—hard common sense and quick perceptions, that permitted them to learn rapidly by experience and by quickness of observation to note the results upon the woods of various conditions in the course of their experiments.

Thus it was discovered, by a more or less costly experience, that in all the long list of varieties of timber hardly any two could be subjected to precisely similar treatment with the best results to both; and it was further found that difference in the source whence the same variety came often required a variation in treatment.

The next and perhaps the most important discovery made, and probably at the expense of the greatest amount of spoiled lumber, was that a temperature too high at the commencement of the drying process produced unsatisfactory results, and often ruined or greatly reduced the value of high-grade and costly material. Before this fact was discovered, so uncertain had been the process in its effects, other than in producing apparently dry lumber, that an actual prejudice arose against submitting upper grades to the artificial process until fairly weather-dried; it being found that if a portion of the moisture on and near the surface was evaporated by the natural heat of the sun, the effect of plunging the lumber at once into a high temperature when put into the kiln was less injurious.

Investigation and experiment proved further that this was a perfectly natural theory and one by which Nature herself worked constantly. It was fully and satisfactorily shown that lumber sawed and piled in the winter so as to take advantage of the first cool, dry days of spring, not only dried in better condition, with much less danger of sap stain, checking, and warping, but that it actually dried more completely to the very center of the piece, and in a shorter time.

This was found to be especially true of thick lumber, it proving to be a fact that, while the winter-sawed thick stuff would often, in favorable seasons, become remarkably dry to the very center,

stock of the same thickness, if sawed and piled during the months of extremely hot weather, would have to be carried over until the approach of another summer, the effect of the season of extremely damp atmosphere seeming to be to liberate the internal moisture, which somehow appeared to be imprisoned by some (at that time) unknown force, and which, being so liberated, was rapidly carried off by the cool, dry days of the following spring.

It had probably always been known that lumber would dry, and did dry, most rapidly during the season of high winds, but the fact had been generally accepted without asking for a scientific reason. But when it dawned upon the minds of the experimenters that there must be one, it led to the further discovery that air in motion of a low temperature would produce better results than air of a high temperature if kept stagnant, and that the ordinary atmosphere, with its natural temperature, if above the freezing point and with a low degree of humidity, if kept in constant motion or circulation, would dry lumber well and rapidly without the aid of artificial heat.

These points once definitely settled and understood, led to researches that immediately led into the domain of wood chemistry and physiology, and the experimenters and inventors became to a degree chemists and physicists. Thus a special education was obtained before they were able to say they had solved the problem of drying lumber artificially; fairly accurate knowledge on the following points being gained:

1. (*a*) Different varieties of wood, and (*b*) wood of the same variety grown in different localities, requiring radically different treatment.

2. (*a*) That too high a degree of heat applied at any stage, and (*b*) especially during the first, injured the lumber more or less, according to kind, and retarded or prevented perfect drying.

3. That with a perfect circulation of air of a low degree of humidity, a high temperature was not necessary to produce good results except as to time.

4. That the results, good or bad, depended very largely upon the chemical changes produced by heat upon the natural gums and juices of the wood.

5. That all these points became much more pronounced in the case of hard woods, and hence the necessity for special machinery and arrangement of the kiln.

THE calculation of the orbits of the newer asteroids has been greatly facilitated at Nice and Bordeaux, France, by astronomical photography, which makes it possible to follow them long enough to give a sufficient number of observations on which to base the computations.

ON ACQUIRED FACIAL EXPRESSION.

By LOUIS ROBINSON.

ALTHOUGH from infancy upward we are all, whether we know it or not, close students of physiognomy, and although a number of books, the result of much careful research, have been published upon the scientific aspect of the subject, there are certain facts connected with facial expression which, though often remarked upon, have never received explanation. With two of these—both of which bear upon the causes of acquired expression of a more or less permanent character—I propose briefly to deal in this article. I refer to the similarity of visage displayed by nearly all members of certain trades and professions; and to the likeness which often becomes apparent on the faces of people (generally married couples) who live together.

In addition to the bony framework, there are three chief anatomical factors which go to make up the expression of the face. These are the skin, the subcutaneous cushion of fat which contains the numerous blood-vessels, and, lastly, the facial muscles. The nerve supply is abundant and peculiar. The integument receives sensory branches from the fifth cranial nerve, the blood-vessels are under the control of the sympathetic system, and the muscles which have to do with expression receive motor impulses from the brain *via* the seventh cranial or facial nerve, first accurately described by Sir Charles Bell. It is to these numerous slips of muscular tissue, with their controlling telegraphic nerve fibers, that I wish especially to direct attention.

It is, of course, obvious to all who have an elementary knowledge of physiology that any movement of any part of the face is owing to the contraction of certain muscles, and that every such contraction must take place at the command of an impulse conveyed to the muscles by means of the motor nerves.

Into the historical evolutionary explanation of these movements it is not my intention here to enter. Let it suffice to say that there can be little doubt that they one and all represent some adaptation of the bodily structures to certain physical needs (possibly long obsolete) which accompanied the emotions of which the movements are now an index; just as the wagging of a dog's tail, which is now regarded as a mere sign of pleasurable excitement, was in the first place of vital importance as a signal to his comrades that game was afoot.

The connection between the muscles of expression and the emotional centers in the brain is of a most intimate character, and is largely independent of the will, although by strong volition any consequent movement of the features may generally be pre-

vented. That the association is instinctive, and not acquired through individual or racial education, is shown by the fact that the facial changes which accompany the sentiments of fear, hatred, contempt, merriment, or mockery are practically identical the world over.

The extreme rarity of the man who can always keep his countenance, even when his will is fully awake, is as complete a proof of this intimate and automatic bond between the mental apparatus and the facial muscles as need be brought forward. Are we not all aware of exercising a restraining effort upon our features when we endeavor to hide our emotions? And is not the common phrase, "He gave way to his feelings," a recognition of the fact that the invariable instinctive tendency is, when the emotions are stirred, to yield to those outward manifestations which are obvious to the eye of another, and which are the results of motor nervous impulse?

Now, this fact is most important in the study of what may be called "static physiognomy," which treats of the interpretation of habitual expression when the countenance is at rest. It shows that in all probability every emotion, however slight, sends an impulse to the appropriate muscles, although the immediate nervous provocation may be much too faint to produce any marked movement. That such trivial and evanescent nerve impulses, although their effect may be at the time unfelt by the subject himself and imperceptible to lookers-on, may be, if often repeated, efficient factors in the formation of a habitual cast of countenance, I shall presently show.

It is plain that such effects will become more perceptible when the first rotundity of youth has disappeared. We naturally look at a young face for a prophecy, and at an old one for a record. But the materials from which we attempt to inform ourselves are of a very different character in the two classes. In the one case we see a general arrangement of features, which, according to some utterly inscrutable law, accompanies certain traits of mental and moral character. No satisfactory theory has ever been put forward to account for such facts as that human beings with a certain inherited squareness of jaw are always of a tenacious disposition.

But when we scrutinize an older face, we peruse the linear inscriptions upon its surface as we read a book of which we know the author. Not only do such and such conformations of its lines have a definite meaning, but we can form an opinion as to why and when (if not *how*) they were written. The caligraphy, of course, is not uniform in all cases, and there are various complexities about it which may render an exact interpretation a matter of difficulty. Trouble or passion, which in one instance is

recorded in bold characters, in another may leave scarcely a visible mark; and it is obvious that a lean face will betray the story of emotional experience more readily than one covered with a mask of fat and smooth skin.

If we look at an anatomical representation of the human face with its integument removed, we see at once that the various groups of muscles are generally so arranged as to balance one another. Thus there is one set of muscles for opening the eyes or the lips, and another set for closing them; one group raises and another depresses the angles of the mouth, and so on. All these muscles, even when the features are quiescent, maintain a certain *tone*; for it is found that if one part of the face is paralyzed, the sound muscles near it draw it toward them and retain it there even when they are at rest. If one of the muscles or groups is stronger in proportion than its opponents, it will cause a marked change of expression, as is plainly seen in partial paralysis. It is a familiar fact that all muscles become larger and stronger through exercise; but the reason why they so increase is not such a simple matter. The vitality of muscular, and indeed of all other living tissue, is strangely under the influence of the nervous system. If the nerves which supply a limb are totally destroyed, it shrinks with extraordinary rapidity, although the main blood supply remains perfect. At the same time a limb may be paralyzed as to motion and yet undergo but little wasting, because certain nerve fibers (called *trophic*, because they have to do with nutrition) are left intact. In bedridden patients, again, in spite of a total want of exercise, the muscles often do not shrink in any great degree. Hence we see that nervous currents or impulses may influence the growth of a muscle apart from actual exercise.

Let us take an instance, the too visible results of which every one is familiar with. Persons who squint (with certain exceptions I need not here specify) are always "far-sighted"—that is, the convex lens of that marvelous living camera, the eye, is not quite convex enough; and in consequence its focus is too long to permit rays from a near object to form a clear image on the retina. If the retina could be pushed back away from the lens the difficulty would be overcome; but we can not, as in the case of an opera glass or a photographic apparatus, lengthen the space between the lens and the spot upon which the image is to be projected to any great extent, so Nature has provided a focusing apparatus in the crystalline lens itself. By a muscular effort the elastic lens can be made more convex, and in this way the focus is shortened to the required length. In long-sighted or flat-lensed persons this is constantly being done when they are reading or looking at some near object.

Now, it so happens that one of the little muscles which move

the eyeball—i. e., the *internal rectus*, which rolls the eye inward toward the nose—gets its nerve supply partly from the same source as do the muscles for shortening the focus of the lens. The latter, in far-sighted persons, are constantly being urged to action by impulses proceeding from the brain along the nerve, and part of the impulse invariably finds its way, owing to the intimate relation of the parts, to the *internal rectus* muscle. This muscle does not at first respond to the stimulus sufficiently to turn the eye inward every time the lens is accommodated for near objects; but the result of this nervous stimulation is in the long run the same as if the *internal rectus* were constantly called into action by a deliberate exercise of the will. It greatly increases in bulk and strength, and outpulls its opponent on the outer side of the eye (which gets its nerve supply from a different source), and so the balance of power is destroyed and a hideous inward squint is produced.

From this we can understand the effect of a long-continued dominant emotion on the face, even although it may exist in an individual too well bred to allow his countenance to be easily distorted by the prevailing passion. Whenever the thoughts take their habitual direction, a stream of nervous influence from the brain to the hidden-expression muscles is the inevitable concomitant. The closest observer may not notice the least change of outline or the vaguest tremor of movement at the time, and the subject himself may be unwarned as to what is going on. Yet in the course of years the muscles so stimulated assert themselves over the others, and a permanent expression in accordance with the mental character comes out.

Close observation of almost any face under favorable circumstances supports this view. While engaged in studying the phenomena of sleep, I have repeatedly noticed that the apparent placidity of the features during slumber is deceptive. Even in dreams each fleeting emotion affects the facial muscles in some degree, and the apparent calm on the surface covers many little eddies and currents beneath, as one or other of them is thus provoked into partial activity. When the thoughts are all-absorbing and the owner of the face is off his guard, it does not require a very acute observer to see how the expression follows what is in the mind.

The other day, while traveling by train, I witnessed the parting of a pair of lovers. The damsel got into the carriage where we were seated, and until the train started there was an eloquent interchange of glances and smiles. As we steamed off, the last smile of parting gradually faded on the lassie's face. She shut her eyes and leaned back, so that she did not see that she was under observation, and at the same time the light showed her

countenance with great distinctness. For the space of some twenty minutes, during which I was her fellow-passenger, the dimples of that parting smile would ever and anon appear, but in so slight a degree that, unless the opportunities for observation had been exceptional, they would not have been noticed. The movements of the muscles were so subtle that it was absolutely impossible to analyze them, or even to discern them severally. They were

> ". . . like the borealis race,
> That flit ere you can point their place."

Yet one could gauge from moment to moment the depth, and to some extent the nature, of her thoughts of her lover.

Let me strongly recommend all physiognomists who travel by rail not to spend their time in the perusal of text-books, while they have before them a row of living documents inscribed all over with the very aphorisms of the art. The opportunities for observation afforded by the British traveling hutch are such as to make one forgive its manifold inconveniences. Take the instance of the old lady who is perturbed about the safety of her ticket and her luggage. Her totality of expression has a heavy groundwork of care, upon which start and flicker endless additional lines, as this or that possibility of trouble crosses her mind. It requires some self-restraint on the part of the enthusiastic student to refrain from making such a one the subject of physiognomical research by hinting various moving hypotheses concerning the perils of the journey or the fate of her numerous packages. Let him not forget, however, that although such experiments are not forbidden by the Vivisection Act, the methods of Parrhasius are out of harmony with the spirit of the nineteenth Christian century.

The incessant flow of involuntary nerve-currents to the facial muscles doubtless accounts for the odd similarity of expression among men of the same vocation. In many such cases the conditions are so complex that it seems impossible to lay one's finger upon the special items of environment which conduce to the facial characteristics exhibited by nearly all members of certain trades and professions. What, for instance, is there about the process of making shoes which evokes the unmistakable cobbler's visage? The portrait of Edward, the Banff naturalist, in Mr. Smiles's book, shows the type in a marked degree. As far as my own observation carries me, the cause must be looked for in the last, lapstone, and wax-end of old-fashioned cordwainery; since men who work the machines in modern boot factories, or who do ordinary repairing, do not exhibit the expression. It appears probable that the tailor's distinctive type of face may have

been partially created by his habit of working his jaws concomitantly with his shears. Let any one watch a person cutting a piece of tough material with scissors, and he will see that the lower part of the face wags in rhythmic and spontaneous unison with the blades. Shepherds and farm laborers who join sheep-shearing gangs certainly acquire a different expression while engaged in this kind of work. The cast of countenance by which one so easily recognizes a groom is partially explicable from the fact that the muscles which close the jaw and compress the lips are always called into play when we are asserting our will over that of a horse. Nearly all jockeys and other horsey men have a peculiar set of the mouth and chin, but I have been unable to distinguish any special characteristic about the eye or upper part of the face. It is instructive to compare the visage of the ruler of horses with that of the ruler of men. The horseman's face shows command in the mouth, the drill-sergeant's in the mouth and the eye. The last is undoubtedly the most effective instrument in exacting obedience from our own species. Here we get a hint of the cause of that want of dignity, that element of coarseness, which is discernible in the countenances of some men and women who have much to do with horses. The higher and nobler method of expressing authority is outweighed by the lower and more animal one.

Generally speaking, it is a strenuous contest with minor difficulties which produces a thin and rigid set of lips. It is seen almost invariably in housewives of the Martha type, who are "careful and troubled about many things," and whose souls are shaken to the center by petty worries within doors, and strife *à outrance* with shortcomings of the scullery maid or the cook.

The compressed lip so loved (and so often misinterpreted) by novelists is a sign of weakness rather than strength. It tells of perpetual conflicts in which the reserves are called into the fray. The strong will is not agitated into strenuous action by the small worries of the hour, and the great occasions which call for its whole forces are too few to produce a permanent impress of this kind upon the features. The commanding officer, assured of his men's obedience, does not habitually keep his lip muscles in a state of tension. Look at the sea captain, the most absolute monarch on earth. He carries authority and power in his face, but it resides in his eye and the confident assurance of his easily set mouth. Every spar and shaft and muscle in his floating realm must obey him, and he knows it. This is probably a reason why the sea captain's and the engine driver's show a certain similarity of type. The engine driver can make his captive giant, strong as ten thousand men, obey the pressure of his finger. His lips are usually calm, like those of the statues of the wielder of thunder-

bolts on Olympus. Who ever saw a man commanding a man-of-war or driving a locomotive with the contentious lip of a school usher?

The typical expressions of the members of those three liberal professions which Sir Thomas Browne says are all founded upon the Fall of Adam are well enough recognized to have been long the prey of the caricaturist. The several distinctive traits of each, and the possible causes which give rise to them, are too complex to be dealt within a single article. Speaking very generally, the cleric's face is indicative of authority (of the thin-lipped kind) and of a dignified sense of the sanctity of his office. The doctor's jaw and mouth are less rigid, yet tell of decision. His eye is vigilant and sympathetic, and his whole facial aspect conveys the idea of a fund of untapped wisdom. The lawyer's countenance is confident and confidential, with a pouncing alertness of the eye, and a prevailing expression of weighty perspicacity.

Of course it must be understood that in such a summary one is dealing with the broadest generalities. Marked exceptions to the rule for each class will be within every one's experience. I am inclined to think that in the learned professions the facial characteristics are much less marked than formerly. This may partly be accounted for by the modern laxity of fashion as to shaving the lip and chin. But also, there can be little doubt that the custom of carrying a sort of perpetual personal trade-mark is diminishing. Military officers no longer wear their uniform in private life, and the doctor and lawyer have both acquired a weakness to be classed, socially, as human beings.

It is noteworthy (and here my own observation has been supported by one of the most alert minds of this generation) that the leading members of the medical and legal professions do not display the facial symbols to anything like the same extent as the rank and file. This is especially so with regard to the expression of the mouth, and may be due to the absence of that anxious endeavor to look like a wise doctor or lawyer which possesses most ordinary practitioners in their earlier years.

The fact that two people who live long together tend to grow alike is accounted for by unconscious mimicry reacting upon the muscles of expression in the same way that a ruling passion does. This tendency to facial imitation is very general—in fact, almost universal—and may be so marked as to be easily noticed; so that when two people are engaged in animated conversation, the expression of the listener may often be seen to echo that of the speaker. How "infectious" is a smile or a laugh, even when the idea which gave rise to it in the first case is not transferred!

Several times, when talking to young people, I have suddenly and purposely adopted some change of expression, such as the

raising of the eyebrows; and this, although not the least apropos to the words spoken at the time, has instantly evoked a like movement on the faces before me. The response was quite involuntary, and was a pure piece of instinctive reflex action. Why does a yawn spread like pestilence through the room when conversation flags? I know of those who have started such an epidemic by a little piece of acting, and not a mouth in the company (save the guilty one) knew why it gaped. Have not we all noticed that a man of marked individuality becomes a center of physical influence to those who wait on his words, so that his gestures, tones of voice, and turns of phrase are reproduced? I know a tutor whose peculiarities of speech and carriage have been adopted more or less by every one of his pupils during the last six years, and several of them have come to resemble him in feature. This unconscious imitation of expression is very noticeable in children. Has it occurred to many careful parents that the good looks of their daughters may depend in no slight degree upon their choice of nurse girls and governesses?

For some reason which we can not fathom, the imitative faculty is so ingrained in us that what the eye perceives the brain makes haste to reproduce without stopping to ask our permission; and where two people live long together the facial muscles of each are constantly receiving stimuli prompting them to mimicry. As in the case of the emotions, these influences may be infinitesimal at any given moment, and may give rise to no visible change of expression. Yet in the course of time they tend to mold the whole countenance, feature for feature, into an almost exact facsimile of another.—*Blackwood's Magazine.*

The most remarkable feature noticed by Prof. Krasnov, of Kharkov, in his study of the distribution of plants in the island of Sakhalin, is the existence side by side of distinct types of vegetation, due to variations, not of climate, but of soil and relief. This, it is suggested, should be a warning against hasty conclusions as to the succession in past times of distinct types of vegetation in Europe, since it appears possible that they likewise existed side by side. In Java, which he also visited, the similarity of the flora on the tops of the volcanoes with that of the polar swamps suggested to Prof. Krasnov problems as to the evolution of polar forms from tropical prototypes.

A case in the Buddhist department of the Gallery of Religions at the British Museum contains an apparatus for exorcising evil spirits which is used by some of the Buddhist sects in Japan. It consists of a brazier surrounded by a small tray for offerings, and bouquets of artificial flowers, the whole encircled by a rope supported on poles. Before this lighted brazier the officiating priest takes his seat, and, reciting appropriate prayers or incantations, burns one by one a bundle of one hundred and eight sticks. Each stick represents one of the wicked spirits "that lead the heart of man into sin," and the exorcism of the whole batch may be assumed to secure a certain immunity from attacks for some time.

SAVAGERY AND SURVIVALS.

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MR. EDWARD A. FREEMAN, the eminent English historian, has given us a short and popular definition of history in the phrase, "History is past politics." While it is true that history includes past politics, and that the political events of to-day become the history of to-morrow, we must acknowledge that the province of history is more extensive than is indicated in this pithy phrase if we are ready to admit, as it seems we should, that the highest end of history is ethical and social, and not merely political.

We can not say that history is limited for its materials to written records; nor do we agree with Morrison,* who says that history is simply literature, and begins with the historical books of the Old Testament.

We really commence our study of history with the first traces of man's presence upon this earth. His bones are to us not only of physiological but of historical importance. His tools, implements, ornaments, and relics are historical records.

Formerly history was altogether written on the artistic plan. We find that many of the most prominent Greek and Roman writers continually sacrificed the truth to literary finish. Since the middle of this century our conception of history has greatly changed. We regard history as a science, and employ scientific methods in our treatment of historical data. Herodotus's conception of history comes to us again in a new light—"ἱστορία," meaning a learning by investigation.

The study of history conveys to us a knowledge of the intimate connection existing between the past and the present. Much of our material for historical investigation we find not in the past, but in living and present things. Archæology will demonstrate this to us. Thanks to the recent discoveries and excavations of the archæologists of the Capitoline Hill, the history of Rome has been entirely rewritten since the French Revolution. How much new light the study of institutions in the primitive times and among the peoples of to-day, whose development has not kept pace with our own, throws upon the origin of the state and of many of our own social institutions!

History brings to us a knowledge of the past to aid us in the settlement of present problems; and so Droysen's ideal comes to us as the highest and best conception of history. "History," he

* Encyclopædia Britannica, article History, by J. C. Morrison.

says, "is the self-knowledge of humanity; it is the potential knowledge of the present with reference to its development from the past." * Thus, history is not politics, not simply the science of government, and a story of revolutions and conquest, nor simply literature; but is more. It is something which includes the history of culture, of law and custom, the development of the family, justice, the social life as well as the political life. It is an unfolding panorama of the self-conscious development of humanity.

History has become more and more sociological in its character, and perhaps this has caused much of the confusion which surrounds the definition of the comparatively new term "sociology." Auguste Comte and Herbert Spencer have shown a disposition to appropriate this scientific conception of history and call it "sociology," giving history a subordinate place under the latter. What the true position of sociology will be in the hierarchy of sciences time alone can settle. Perhaps we shall ultimately call history in the scientific sense "sociology," putting it, as Comte and Spencer do, at the head of all the sciences, or perhaps we may make of it a philosophy of society, dealing with universal laws and universal types, for which history, its chief adjunct, will furnish the data; or we may regard sociology in a way similar to the popular conception of it at present, as the science which deals with social problems.

It is, however, institutional history or historical sociology that is so attracting the attention of scholars at the present time. There is no study, perhaps, so attractive as the study of primitive society, the habits and customs of savage life, the development of culture and of moral and religious ideas; while its chief profit lies in the solution and understanding of our own progress and development in a continuous line from the historic past. If we would understand the development of our modern state, we must study the beginnings of family life and government, the evolution of the state from the family. To deal intelligently with the divorce problem in modern society, one must study the origin and early history of marriage, and approach the solution of the problem from the historical point of view.

In many of our ceremonial institutions, our fashions, habits, dress, ornamentation, opinions, notions of marriage, property, and law we are but the slaves of the customs and traditions of the past. It may be of interest to look at some of these habits and customs of savage life. We might ask the question, "How is the course of civilization traced?" One means is through the aid of survivals. And what do we mean by "survivals?" "Those

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* Droysen's Principles of History.

opinions, customs, and peculiar notions of ours which require an explanation for their presence and which represent an older period of culture." * The Hindu, for example, continues to use the primitive fire-drill for kindling the sacred fires, although the lucifer match is used for all other purposes. Catlin noticed a similar custom among many Indian tribes of North America. The ancient Eygptians continued the use of the stone knife in the religious rite of circumcision long after the introduction of the metals. The institution of marriage to-day offers us illustrations of ceremonies which seem a necessary part of the institution; and yet, if we were asked for rational explanations of them, we should be at a loss to explain, were we not able to appeal to the evidence of history and call them survivals.

How can we explain the wedding cake, the bridal tour, the storm of rice and old shoes accompanying the departure of the happy couple, without an appeal to the customs of the past? The coyness of the maiden to-day is fully equaled by that of the savage maiden. It is customary with the latter to manifest opposition to entering the paths of matrimony, though that opposition in some cases is merely feigned. This probably originated—as most writers agree—among nations who were in the habit of capturing their wives from hostile tribes, but it has lingered as a conventional observance in cases where the change of state is not distasteful. Marriage by capture is not uncommon, and prevails among some of the Hindu tribes, Circassians, and the primitive races of Australia, New Zealand, and America; and survivals of this custom to-day would seem to indicate traces of this institution among the early Aryan and Semitic races. The rape of the Sabines affords a good illustration of this custom among the early Romans.

The primitive form of marriage by capture, however, gave way later to the ceremony of marriage by purchase, a price being paid by the groom to the parents of his bride, and the marriage contract being settled generally without the latter's consent. In this second stage, where the bride was secured by a more peaceful method, the violence accompanying the former mode of securing a wife still lingered in the form of a survival. In turn, the custom of purchasing a bride passed from the stage of reality to the ceremonial stage. Among the New-Zealanders a bride is only secured after a prolonged struggle between the friends of the groom and the friends of the bride. Among certain tribes of India the groom is obliged to overcome a strong man who is appointed to defend the bride. A curious parallel to this is noted among the Eskimos. The youthful candidate to matrimony is

* Tylor's Primitive Culture, vol. i, chap. iii.

only qualified to marry after he has succeeded in killing a polar bear without assistance. This is taken as an evidence of his ability to provide for the wants of the household. In Turkey a prominent part of the ceremony is the chasing of the bridegroom by the guests, who strike him and hurl their slippers at him. And what adds zest to the occasion is the fact that these onslaughts are usually led by the females who were disappointed at the loss of a former lover. Another survival of marriage by capture is discovered among the Ceylonese, where it is common at royal marriages for the king and queen to throw perfumed balls and squirt scented water at each other.

As stated above, even in the latter stage of marriage by purchase, where the marriage contract is settled on a friendly basis, the symbol of capture is still maintained. For example, after the purchase price is agreed upon, the girl is given the privilege of running for her independence. This is known as "bride-racing," and takes various forms. In one instance, the girl is mounted on a swift horse; she is given a good start, and then pursued by her lover similarly mounted. If he overtakes her, she becomes his bride. If not, the marriage is declared off. As a rule, however, after a little exciting sport, the girl allows herself to be overtaken.

Among other tribes, we find the symbol of capture perpetuated in the foot race, or water chase in canoes; or the race may be run through a series of tents, as observed by Mr. Kennan in Siberia. In this case all sorts of obstructions are placed in the way of the groom by the friends of the bride, and if he be successful in running the gantlet and jumping the improvised hurdles in time to catch the girl he becomes a Benedict. It is also a custom for the "fair one," if she be more fleet-footed than her lover, to wait kindly in the last tent until he joins her.

Thus it is general among uncivilized peoples to accompany the wedding ceremony with violence of some sort. Kicking and screaming on the part of the bride are considered an evidence of modesty; and the stouter her resistance and the more violent her convulsions, the greater is she appreciated ever after by her husband and her own friends. It is said even to-day that the young girl hardest to woo is best appreciated by her lover.

Marriage among the Greeks and Romans consisted of three acts: First, the quitting of the paternal hearth; second, the conducting of the young girl to the house of her husband, accompanied by relatives and friends and preceded by the nuptial torch. Then the act of violence survives in the following, the third part of the ceremony; for at this point it was the duty of the groom to seize the bride and carry her into his house without allowing her feet to touch the sill. Around the domestic hearth the hus-

band and wife now gather, offer sacrifices, say prayers, and eat of the sacred wheaten cake. This last performance, which still survives in our wedding-cake of to-day, was of great importance, as it cemented and sanctified the union of the two, who were now associated together in the same domestic circle and the same worship.

The wedding feast is of ancient origin, and probably originated, as Westermarck points out, in the purchase stage, where the feast was regarded as a part of the purchase price paid by the groom; or, in cases where the expenses were met by the parents of the bride, as part compensation for the sum of money paid for the bride. The custom of giving presents to the bride is also interesting in its origin. In all probability it also came from the purchase sum paid by the groom to the family of his bride, this purchase sum degenerating into a mere present, more or less arbitrary, which in some cases was returned to the giver; in others, given to the bride. In Athens, during an early period, the dower was known, for the bride was frequently provided with a marriage portion by her father or guardian. This led to the giving of presents by the bridegroom to his wife. It was a common observance for gifts to be exchanged between the bride and groom or their guardians, and numerous instances of this are recorded. It is a part of the ceremony in China and Japan; and Tacitus relates a similar custom among the Germans. Thus the custom of giving the bride a good start in life with the aid of presents is not new; while the bridal tour, and the practice of throwing rice and old shoes after the departing bride and groom, are symbols of the violence that formerly accompanied the marriage ceremony. Even more dangerous weapons were used within recent times, for it is related to have been a custom among the Irish to cast darts at the bridal party. On one occasion, however, a certain Lord Hoath lost an eye by the foolish practice, and since that time it has become obsolete, less harmful weapons having been substituted. The "best man" of to-day was formerly the chief lieutenant of the groom in the act of capturing his bride, while we find the wedding ring in use among the ancient Hindus. Among the Ceylonese the latter takes a curious form, for "the bride ties a thin cord of her own twisting round the bridegroom's waist, and they are then husband and wife." * This he wears through life as an emblem of the union. The ceremony would indicate that among these people the woman is "the boss." This, however, is contrary to the usual custom which we find among many other tribes, for the boxing of the bride's ears by her husband to indicate that he is master is an important part

* Westermarck's The History of Human Marriage, p. 420.

of some ceremonies, while it is said that in ancient Russia the father, taking a new whip, would strike his daughter gently, and then hand it over to the groom, indicating thereby that a change of master had taken place.

The blood-feud or revenge offers a field of similar interest to a student of legal and institutional history. Formerly, before the age of judges, state prisons, and reformatory institutions, it was the custom for an individual to take the law into his own hands. "Self-help," says Farrer, "is for individuals the first rule of existence. But generally this deficiency in the legal protection of life and property is made up for by a principle which lies at the root of savage law—the principle, that is, of collective responsibility, of including in the guilt of an individual all his blood relations jointly or singly." * One can see upon reflection why the avenging of murders or wrongs committed should be regarded as a family or tribal rather than a personal affair, on account of the powerful influence it must have in repelling crime and keeping the public peace. A good illustration of blood vengeance we have among the native Australians to-day, where it is regarded as one's holiest duty to avenge the death of his nearest relation. The force of public opinion compels the man to do his duty by his relative. It is the custom among a certain Brazilian tribe for the "murderer of a fellow-tribesman to be conducted by his relatives to those of the deceased, to be by them forthwith strangled and buried, in satisfaction of their rights; the two families eating together for several days after the event as though for the purpose of reconciliation." But the affair is not always so happily and permanently healed, for if the guilty one escape the avenger slays his nearest relative. Consequently, it was a matter of the greatest importance that the punishment should be visited upon the real culprit, and frequently both families united in hunting down the murderer. But more often, where the innocent received the punishment due the guilty, hereditary feuds sprang up between the tribes, and tribal warfare resulted.

The right of revenge was a recognized principle of the Jewish law, as seen in the following quotation from Exodus: "And if any mischief follow, then thou shalt give life for life, eye for eye, tooth for tooth, hand for hand, foot for foot, burning for burning, wound for wound, stripe for stripe." † It was likewise a right recognized by the law and custom of the Germans. In time the right of revenge gave way and certain modifications of the old institution were made to relieve its severity. This was probably due, as Tylor suggests, to the increase of population and the growth of town life. Among the Jews the right of revenge was suspended on

* Farrer's Primitive Manners and Customs, p. 163.

† Exodus, xxi, 23–25.

certain festival days, and cities of refuge were established, whither the criminal might flee and be safe; or, as in Western Australia, "crimes might be compounded by the criminal committing himself to the ordeal of having spears thrown at him by all such persons as conceive themselves to have been aggrieved," care being taken, however, to limit the punishment in such a way that the prisoner might escape without mortal wounds. But the law in the interest of peace and progress soon fixed upon a composition for the crime, known as "*wergild*, or man-money." Such was the practice of our Anglo-Saxon forefathers less than a thousand years ago, when the *wergild*, or fine, of which our judicial fines are a survival, was regarded a fitting substitute for personal vengeance. The survival of the law of retaliation, as expressed in the passage from Exodus, is seen in the composition provided for each part of the body. The teeth, hair, nails, and other parts had their peculiar value, the hair being especially prized. For instance, the loss of the beard was estimated at twenty shillings, while a broken thigh was worth only twelve. The loss of a front tooth was reckoned at six shillings and a fractured rib at three. The composition for a freeman was two hundred shillings, or half price for the loss of a foot or hand, five shillings for the little-finger nail, and so on. There is one point, however, that deserves notice in this connection. The value of a man varied according to his rank, the royal *thegn* or lord being rated as high as twelve hundred shillings. While impartiality with regard to rank or wealth is the rule of justice in all civilized communities to-day, yet in many instances it seems as difficult for our courts and juries to overlook these factors as it was in Anglo-Saxon law, and the big embezzler stands an infinitely greater chance of escaping punishment befitting the crime than the petty thief.

Our criminal law grew out of the old private vengeance, but in accordance with modern ideas the state, representing the community, has become the avenger. While the older method of family responsibility went a long way toward securing orderly government, it has given way to the better plan of holding the individual responsible, though the traces of the former still linger on in the ignominy which seems even in these days to attach to the relatives of a criminal.

When we speak of the vengeance of the law, the old idea that the law is being avenged by the punishment of the criminal is revived; but the prevailing idea in dealing with the criminal classes is that punishment is exacted for the benefit of society and for the repression of crime. The public prosecutor stands in the place of the avenger, and witnesses may be compelled by the state to appear in the interest of the public peace. The blood-

feud, or vendetta, still lingers as a survival almost in our very midst, in the mountain regions of our South. It is not an uncommon thing to read in our papers of the perpetration of some atrocious crime as the result of a long-standing feud between the Hatfields and the McCoys, the Frenchs and Eversoles, or the Jarvises and the Kendalls. And it is surprising that often when the law once gets its grip upon these modern savages it does not repress them by a wholesome administration of justice. As a matter of fact, it is difficult to secure a conviction or anything more than a very light sentence for a willful aggressor in our Southern vendetta.

The international prize fight is a degenerate suggestion of the old tribal champion, who was appointed to defend his country in single combat against the representative of a hostile nation. Of this primitive institution, the familiar stories of David and Goliath, and the Horatii and the Curatii, are good illustrations. Passing now to a different branch of our subject, let us glance at a few peculiarities of savage life with regard to dress, ornamentation, and bodily disfigurements. On these subjects Prof. Frederick Starr's recent articles* in The Popular Science Monthly will be found full of interesting and suggestive facts.

It is a matter of uncertainty how dress has developed until it has reached its present form among civilized peoples. While it is probable that the desire for ornamentation, which is usually the first thought in the savage mind, led to its adoption and development, protection and modesty also contributed; for, as Tylor says, it was a custom among the Andaman-Islanders to plaster themselves with a mixture of lard and clay as a shield against the heat and mosquitoes. Among the rudest races, and even in the warm climates, we find clothing worn, or, as a fitting substitute the body is painted, tattooed, or plastered, as described.

It was an early custom to wear a girdle about the waist, and from this suspend skins, feathers, and other ornaments. In time this led to the wearing of a loose robe for the covering of the body, which is known as the southern type of dress, so common in the Orient, notably in China, Japan, as well as in ancient Egypt, Greece, and Rome; while in the north, where the climate demanded the greater protection of the body, the close-fitting garment, including jacket and trousers, at first made of skins, became the prevailing costume. The Eskimos, for instance, have long worn this type of dress. Skins and furs made the most durable garments, and as a covering for our feet we have yet to find something to supplant this inheritance of savage times. In the

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* Popular Science Monthly, August, October, November, December, 1891. Articles on Dress and Adornment.

absence of skins, the leaves of the forest were used for costuming, and one is often reminded of this savage custom in the diversions of the rural picnic party, when the leaves of the forest are woven into primitive garlands and aprons. In Brazilian forests Nature is especially kind to the savage, for upon the "shirt tree" is grown the ready-made garment. All the native has to do is to remove the bark of the tree, cut slits in it for armholes, soak and soften the bark, and then place it upon his body. The plaiting of mats for clothing, followed by the invention of the loom, and the weaving of cloth are interesting processes connected with the development of dress.

In contrasting the close-fitting garment of the northern type with the loose-fitting or blanket type of garment in the South, Prof. Starr is led to make the suggestion that this accounts for the two prevailing types of dress which exist in civilized society to-day. One of the great conservative elements in society is woman, who stands as a useful brake upon rash and too impetuous change. "The northern and southern types of dress once came in conflict. The time was that of the invasions of the northern barbarians upon imperial Rome. Both men and women, in the ancient days of Rome, wore the southern dress. The barbarians wore the tighter-fitting garments of their colder climate. The southern man adopted the more convenient type, the woman did not; and so we see to-day our men in jackets with tight sleeves and close-fitting trousers, while women continue to wear in a modified form the dress of the sunny South—flowing garments, skirts and cloaks." *

We are reminded of this southern type of dress in the spotless robes and vestments of the priest and chorister; and it is not difficult to see in the cap-and-gown fad, which has recently attacked our colleges with the vigor of a prairie fire, a survival of this classic type of dress.

A curious costume is that of the medicine man, the most unique and important individual among savage races. His object is to terrorize his patient by his grotesque costume, his weird movements and incantations, and to kill or cure as the case may be. Catlin gives a picture of one and describes his movements. His body and head were covered with the skin of a yellow bear, the head serving as a mask, a rare and conspicuous thing to begin with. "The huge claws dangled upon his wrists and ankles. In his right hand he shook a frightful rattle, in the other he brandished his medicine spear or magic wand." † The medicine man ordinarily administers to his patient roots and herbs, and if these

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* Popular Science Monthly, October, 1891, p. 800.

† Smithsonian Report, 1885, Part II, pp. 417–419.

fail, then as a last rite he arrays himself in his strange dress and goes through his hocus-pocus over the dying man, with the expectation that his mysterious and magical skill may be invoked at this point to save the patient. In case of an adverse result, however, he easily maintains his self-respect in the community by the explanation that "it was the will of the Good Spirit." An illustration of savage logic is also interesting in this connection, for the medicine man argues by analogy that extraordinary cases demand extraordinary remedies. Dorman relates an incident which seems to substantiate this. "An Indian warrior was brought to camp after a most disastrous encounter with a grizzly bear. The doctor compounded a medicine that ought really to have worked wonders. It was made by boiling together a collection of miscellaneous weeds, a handful of chewing tobacco, the heads of four rattlesnakes, and a select assortment of worn-out moccasins. The decoction thus obtained was seasoned with a little crude petroleum and a larger quantity of red pepper, and the patient was directed to take a pint of the mixture every half hour. He was a brave man, conspicuous for his fortitude under suffering, but after taking his first dose he turned over and died with the utmost expedition."

Savages are very fond of ornaments, and in some respects we resemble them—with this difference, that in savage life it is the men who are the most highly decorated. The incentive of personal adornment was, as it is now, due to the desire to make one's self prominent or conspicuous in the eyes of others. As proud as the schoolboy is of his medal received as a reward of merit, so is the savage of his trophies, which he wears as a mark of his prowess in battle, or in an encounter with some wild beast. Necklaces, bracelets, and earrings made of these trophies were among the earliest ornaments worn. Teeth, claws, shells, pearls, ivory, bone, hair, and feathers were commonly used, while the brass plates for keyholes, sardine boxes, and other metallic objects are said to be especially prized. On the arms circular rings of ivory, iron, or copper were worn, and the savage delights to load himself to the extent of physical endurance with these heavy and useless appendages. Schweinfurth, the African explorer, thus describes the ornaments of the Dinka, a Central African tribe: "The wives of some of the wealthy are often laden with iron to such a degree that, without exaggeration, I may affirm that I have seen several carrying about with them close upon half a hundred weight of these savage ornaments. The heavy rings with which the women load their wrists and ankles clank and resound like the fetters of slaves. . . . The favorite ornaments of the men are massive ivory rings, which they wear round the upper part of the arm; the rich adorn themselves from elbows to wrists with a whole series of rings,

close together so as to touch."* It is said that an African princess, who had her arm covered from wrist to shoulder with these curious bracelets, suffered so much from the heat of the sun playing upon these rings, that she was obliged to hire a maid, whose duty it was to attend her constantly and cool them from a watering pot.

Thus the different parts of the body—the neck, arms, and ankles—which Nature has so abundantly provided for the carrying of ornaments are utilized; and, what is still more curious, the savage, not satisfied with this, cuts holes in himself for the purpose of carrying others. The most frequent mutilations are those of the lip, cheek, nose, and ear. Some curious illustrations of this custom are related by Schweinfurth. The upper lip is pierced, and there is inserted a round-headed copper nail or a copper plate. Among the Bongos, the women suffer a hideous mutilation for the purpose of extending the lower lip. A hole is bored in it, and in this a wooden plug is fitted, which is gradually enlarged until the lip is five or six times its original size. In this way, by wearing these plugs, which are an inch in thickness, the lower lip remains extended beyond the upper, though the latter is similarly pierced and fitted with a smaller copper plate or nail or bit of straw. The lips are similarly extended sometimes by the insertion of circular plates of quartz, ivory, or horn the size of a half-dollar. These cause the lips to rest in a horizontal position, and when the wearer is in a fit of anger have their advantages, for these cymbal-like attachments on the lips add noise and effect to the chattering of the individual. It is likely that the wooden or quartz plug which is so often inserted in the lower lip was suggested by the horn of the rhinoceros. Not content with labial adornment, they attack the nose in the same manner, small bits of straw being fitted into each side of the nostrils. Occasionally the cartilage between the nostrils is pierced, and a wooden plug or copper ring is worn. This is a common sight among Indian tribes. The ear is often pierced in many places, sufficient to carry a half dozen rings. The slitting and the stretching of the ear is also a common practice. Mr. Catlin gives a picture of a chief in a Delaware tribe, "Lay-law-she-kaw"—i. e, "He who goes up the river"—who had his ears slit and elongated to the shoulders, through the wearing of heavy weights in them at times. When on parade, he made use of them as quivers, carrying in that way a bunch of quills or arrows for the sake of ornament. Other savages use them for the carrying of snuffboxes or knives; and I have known a Chinaman in these days to make use of his ear as a pocketbook, in which he carried

* Schweinfurth's The Heart of Africa, vol. i, p. 153.

his car fare until called for by the conductor. Just as the dress or bodily ornaments characterize the tribe, so does the peculiar style of disfigurement serve as a tribal mark as well as a decoration. Some file the teeth in fantastic shapes; others bore and stud them with brass nails. Among some African tribes it is the custom to break off the lower jaw teeth. Sometimes they are filed to a point for the purpose of griping the arm of an adversary in wrestling or in single combat.

In tribal or family distinctions they do not stop here, for body-painting, tattooing, gashing the face and body were used for the purpose, while the savage can give the moderns many valuable points on dressing the hair. "The ancient Egyptian woman had blue hair, green eyelashes, painted teeth, and reddened cheeks, while the modern Egyptian follows similar fashions, prolonging the eyes by means of a drug, staining the nails brown, and painting blue stars on the chin and forehead." One does not have to go far in our own land to find a physiognomy as artificial in its makeup as that of the savage or Egyptian; while the painted face of the savage and the Indian is still kept before us in a more grotesque and ludicrous form in the curiously painted face of the circus clown.

Tattooing is a mode of ornamentation adopted by a great number of savage tribes, but with the development of dress, skin decorations cease, and as we get higher up in civilization but few remains of these savage customs are found. Our sailors, however, have shown a considerable degree of conservatism in preserving this custom.

Gashing is one of the most curious of all practices. "In South Africa, the Nyambanas," says Lubbock, "are characterized by a row of pimples or warts, about the size of a pea, and extending from the upper part of the forehead to the top of the the nose. . . . The tribal mark of the Bunns (Africa) consists of three slashes from the crown of the head down the face toward the mouth; the ridges of flesh stand out in bold relief. This painful operation is performed by cutting the skin and taking out a strip of flesh; palm oil and wood ashes are then rubbed into the wound, thus causing a thick ridge upon healing. . . . The Eskimos from Mackenzie River make two openings in their cheeks, one on each side, which they gradually enlarge, and in which they wear an ornament of straw resembling in form a large stud, and which may therefore be called a cheek stud." *

I am told that now some young women occasionally submit to a rather painful surgical operation for the removal of a piece of

* Lubbock's Origin of Civilization, chap. ii, p. 59.

flesh from the chin or cheek, the result being, upon the healing of the wound, the appearance of a coquettish dimple.

With the progress of civilization, the tendency is to dispense to a greater or less degree with the various forms of bodily ornamentation, and the most painful operations for the adornment of the person are given up first. The piercing of the ear, however, is still common, and continues to remind us of the customs of savages, but perhaps the day is not far distant when the earring, the bracelet, the superabundant finger-ring, the costly diamond necklace, and other reminders of savage life and social inequality may give way before the spirit of democracy which is coming to prevail more and more in our social as well as political life. And yet we must not underrate the importance that these facts from savage life have played in the world's progress. The dude, as Prof. Starr reminds us, occupies an important place in the history of culture, for personal vanity and the desire to emphasize one's individuality have done much toward the development of our æsthetic senses, and as well for the arts and sciences, and for the cultivation and satisfaction of wants outside of the mere primitive needs of food and clothing.

One might go on multiplying by the hundreds illustrations of the peculiarities of savage life, and suggesting interesting and curious survivals, but the scope of a single short article would not permit the mention of a great variety of topics that properly come within the field of primitive institutions and survivals. Volumes of interesting facts have already been gathered upon this vast and comparatively new department of study, and any one who enters upon it will increase his respect for the advantages which modern civilization has brought to us. If we examine, from the historical point of view, language, customs, mythology, mathematics, jurisprudence, property, folklore, morals, religious beliefs and superstitions, we shall find "savage opinion in a more or less rudimentary state, of which civilized man still bears the traces, and over which state he represents the greatest advance." We hear of the "freedom of the savage," but we need to remember that he is utterly dependent upon Nature for his support and is a slave to his own passions. It is estimated that it requires fifty thousand acres, or seventy-eight square miles, for the support of one man in the primitive hunting and fishing stage; consequently, as their numbers increase they are driven to cannibalism in self-defense. But with the progress of civilization, man increases his dominion over Nature, and, as a rule, we find the most highly civilized countries those where the population is densest and production greatest. Our great World's Fair presented us with a magnificent object lesson of man's power over Nature. The marvelous rapidity of

our progress within recent years, the numerous discoveries and inventions for shortening time and space, increasing production, combating disease, etc., seem almost to indicate that we are scarcely more than upon the very threshold of civilization. To quote a short sentence from Tylor, "The unconscious evolution of society is giving place to its conscious development, and the reformer's path of the future must be laid out on deliberate calculation from the track of the past." * If this be our understanding of scientific history, then we accept the conception of history with which we started—that is, we agree that "history is the self-conscious development of society."

SKETCH OF HEINRICH HERTZ.

By HELENE BONFORT.

WHEREVER the investigating minds of scientists are at work promoting the insight of man into the mysteries of Nature, wherever friends of natural philosophy are keenly alive to the importance of this comparatively new field of study, a field in which lie some of the most essential interests of modern civilization, there will be sincere and deep regret over the death of a young professor whose splendid career came to an untimely end on the first day of this year. Prof. Heinrich Hertz, of the University of Bonn, in Germany, died on January 1, 1894, not yet thirty-seven years of age. For the last two years he had not been in good health, and, though under the treatment of his capable physicians he several times rallied and seemed to be restored to his former strength, the last winter brought a serious relapse. A chronic and painful disease of the nose spread to the neighboring Highmore's cavity and gradually led to blood-poisoning. He was conscious and in possession of his full mental power to the last; he must have been aware that recovery was hopeless, but not a word escaped his lips that would have shown to his dear ones whether hope or fear filled his heart. His wife and his mother were at his bedside for many weeks, giving him their tenderest care, and, in spite of his continuous sufferings, there were many hours of genial discourse. At such times they read to him, and he gave himself up to general topics and to matters of personal interest to them, displaying even yet his wonted brightness and cheerfulness.

Heinrich Hertz, born in Hamburg on February 22, 1857, was the eldest son of exceptionally good and clever parents. His

* Contemporary Review (article on Primitive Society), vol. xxii, p. 72.

father was, at the beginning of his career, a lawyer; in due course of time he rose to the position of judge of the Supreme Court of Appeal, and has now been for a number of years a senator of the free city of Hamburg. The childhood of Prof. Hertz was subject to every pure, healthful, and elevating influence that a highly capable father and a superior mother can exercise. Both of them gave a great part of their time to their children; their eldest boy especially enjoyed the advantage of their companionship in many a holiday's ramble through the green fields and woods, and in cozy winter nights spent in reading Homer, the German classics, and other books.

In passing through the high-school classes of his native city, his predilection for the study of natural science early asserted itself. Whenever a new course of study began and a new text-book was put into the hands of the class, the boy would devote every leisure moment to the perusal of the volume, experimenting frequently with apparatus made by himself, and never ceasing until he could tell his father, "I have mastered that book." This statement always proved to be perfectly correct. In spite of his decided gift for natural science, Hertz chose as his vocation civil engineering. But when, after completing his studies, he came to take the first steps toward the practical execution of this design, he felt that his choice had been a mistake. His parents, with a ready perception of the deeply rooted needs of his strong and peculiar nature, whose desires they would not think of thwarting, entered into his new idea, gave him their approval, and furnished him with the necessary means. So he set out on a new course of studies in mathematics and natural science. He gave himself up to this work heart and soul, and for a number of years knew no other object in life but unceasing and unrelenting hard work. He studied physics at Munich and Berlin, and enjoyed the warm regard of Prof. Helmholtz. In 1880 he became his assistant, and, at his instigation, in 1883 settled down as a "Privat-docent," or professor without salary at the University of Kiel. It was from this time on that he made the science of electricity the one great object of his researches, the main pursuit of his life. The first years were filled with investigations relating to electric discharges, etc. He busied himself, above all, with the new conceptions of the inner mechanism of electric phenomena, and of the connection between these and the phenomena of light and of radiant heat. These conceptions, originating with Faraday and Maxwell in England and represented in Germany by Helmholtz, were now carried forward by Prof. Hertz.

His reputation soon spread through his native country and he was in 1885 called to the Polytechnic School of Karlsruhe, which for various reasons became very dear to him. One of its attrac-

tions was the exceptionally fine and well-endowed laboratory of the institution, which furnished the most desirable facilities for unlimited experimenting. At Karlsruhe Prof. Hertz found a wife who was in every way a lovely and graceful, devoted and highly intellectual companion to him. His life was from this time on divided between the pursuit of his main object, the progress of science, and home happiness; both he and his wife derived rare gratification from literature and the beauty of Nature. It was from Karlsruhe that he went to Heidelberg, there to enjoy the proudest moment of his life, in the year 1889, when, greeted with enthusiastic applause by most prominent scientists, he stood up on the platform to tender an account of his researches and their results. Who that saw him there, the very picture of youthful vigor and life, could have foreboded that those fine and penetrating eyes, to which for the first time since our earth turned around its poles electric waves had been revealed, were so soon to be closed in death!

Soon Prof. Hertz received flattering calls to the most prominent universities; he preferred the smaller town of Bonn, where he settled down in 1890, even to Berlin, the capital, because what he sought after was the most serious and fruitful work, not glory and outward advantage. In Bonn he succeeded to the eminent physicist, Prof. Clausius; this was in itself a high distinction conferred upon so young a man as Prof. Hertz. Considered all over Europe as one of the most prominent, he was looked up to as one of the most promising leaders in the science of electricity. Not only had his own country conferred high honors upon this young and ardent worker, but the chief academies of England, France, Italy, Austria, and Russia now crowned his efforts with prizes, honorary memberships, and other tokens of universal esteem and gratitude.

Up to the middle of this century the phenomena of electricity and magnetism had been only inadequately explained by applying to them Newton's law of gravitation and asserting that, in the same way as celestial bodies exercise power of attraction at a distance and without the intervention of a medium, the two kinds of material electricity were attracting and repelling each other, while passing through space or through non-conductors.

It was the great English physicist Faraday who first sought to carry the knowledge of electricity to a higher stage, by entering upon the study of phenomena with a mind free from preconceived opinions. He put forth as the foundation on which to base new theories his observations of electric and magnetic forces, their influence upon each other, their attractions for material bodies, and their propagation by the transmission of the excitation from one point of space to another. He questioned the

assumption of space being void, and conjectured that the ether which transmits the luminous waves suffers modifications perceived under the form of electrical and magnetic manifestations. His discoveries, important as they were, gained due consideration only when Faraday's great countryman, Maxwell, treated the same subject in a purely scientific and theoretical way, publishing in 1865 his Mathematical Theory of Light. The nature and properties of ether he left undecided, and they form to this day dominant questions, destined, it seems, ultimately to reveal the deepest secrets of natural science. Maxwell labored to confirm the connection, surmised by Faraday, between light, electricity, and magnetism; the idea of velocity now entered the theory and became of supreme importance. Maxwell arrived at the conclusion that the velocity of electromotion in a given medium must be identical with the velocity of light in the same medium, and that therefore ether, being contained in all ponderable bodies, would have to be looked upon as the conductor of electric motion and power. Consequently the periodical motions of ether, which our eye conceives as light, and which he figured as transversal waves, were considered by Maxwell to be at the same time undulations of electricity. These conceptions, unproved by experiment as Maxwell left them, had merely the value of a scientific hypothesis emanating from a man of rare genius. To have proved them facts, and thereby to have united two vast and highly important domains of natural philosophy, is the lasting credit of Prof. Hertz.

The complexity of phenomena of light and electricity and the insufficient opportunities afforded by the laboratory for deductions of such magnitude rendered the obstacles barring the road to exact observation well-nigh insurmountable. Many of the best and ablest naturalists were laboring to cope with these difficulties. Two English scientists of highest standing, Prof. G. F. Fitzgerald and Dr. O. T. Lodge, were during the eighties occupied with experiments for the investigation and measurement of electric waves. But it was reserved for Hertz to discover and apply with marvelous ingenuity the necessary "detector," a resonating circuit with an air-gap, the resistance of which is broken down by well-timed impulses, so that visible sparks are produced. After an unceasing course of experiments, in which he manifested indefatigable energy and a wonderful faculty of reaching the very essence of the matter, he succeeded in deciding the questions: Is the propagation of electrical and magnetic forces instantaneous? and further: Can electrical or magnetic effects be obtained directly from light? The paper On very Rapid Electric Oscillations, which was published in 1887, was the first of a splendid series of researches which appeared in Wiedemann's

Annalen between the years 1887 and 1890, and in which Hertz showed with ample experimental proof and illustration that electromagnetic actions are propagated with finite velocity through space. These twelve epoch-making papers were afterward republished—with an introductory chapter of singular interest and value, and a reprint of some observations on electric discharges made by von Bezold in 1870—under the title Untersuchungen über die Ausbreitung der elektrischen Kraft. A translation of this book, entitled Electric Waves, by D. E. Jones, B. Sc., with illustrations and a preface by Lord Kelvin, has just been published in England.

In 1889, when laying before the Congress of German Naturalists at Heidelberg the results of his labors, Prof. Hertz, with the modesty characteristic of the true investigator, the utterly unassuming disciple of science, gave ready and graceful acknowledgment to the efforts made by his predecessors or co-operators in the work, some of whom had all but attained the results which they aimed at and which he achieved. It is pleasant to recollect that when he had gained the end toward which they also had been striving, the English professors, Oliver Lodge and Fitzgerald, were foremost in announcing his success, and in preparing the English-speaking world to appreciate the importance of his discoveries. A natural bent of mind toward the questions at issue had awakened the young professor's creative powers; his complete concentration upon the vital point and his intuitive perceptions led him to definite results and complete success where so many able minds had searched in vain. In the April number of this magazine Herbert Spencer, speaking of the late Prof. Tyndall, gives a number of traits that apply with singular force and exactness to Prof. Hertz. Of these the first is "the scientific use of the imagination." It may well be said that with this constructive imagination, as Mr. Spencer terms it, originated Prof. Hertz's rare success as a discoverer and as an instructor.

To find out the most effective arrangement of electrical conductors and to secure the conditions which would produce the strongest vibrations at regular intervals and in quickest succession, we might say the adjustment of his instruments was the first part of his work. Having brought about electric undulations up to several hundred millions in one second, Hertz proved through experiment that the waves of electricity are transversal like those of light, and that the transmission requires a certain lapse of time. He ascertained exactly the velocity of electricity; it is found by multiplying the length of wave, which he measured, by the duration of the vibration, which can be calculated, and he found this velocity to be, as Maxwell had supposed, equal to that of light, and, moreover, equal to the velocity of electric waves in

metallic wires. The grand consequence of this last discovery was the cognizance of a new fact: that what had hitherto been considered as a current of electricity *in* a wire is really a movement along the surface of the wire. Maxwell's magnetic theory of light found further corroboration by the experimental demonstration of electric power as propagating from its center in waves similar to sound. The electric undulations are subject to the same process of reflection, refraction, absorption, etc., as the rays and waves of light, from which they are in the end distinguished only by their considerably greater length, measured sometimes by kilometres. The crowning experiments of this course finally changed what had hitherto been looked upon as a coincidence between two orders of distinct phenomena into a demonstration of identity. By gathering the electric spark in the focus of a large concave mirror, whence it came forth in the form of a rectilinear beam, the properties of the electric ray were shown to be identical with those of a luminous ray, the former producing phenomena which have heretofore been observed only in light—those of polarization. This result renders all theorizing on the matter superfluous: the identity of the two powers springs from the experiment itself; ocular proof is produced for the proposition that light is in its very essence an electrical phenomenon, whether it be the light of the sun, of a candle, or of a glowworm. Suppress electricity in the universe—light would disappear. Suppress the luminiferous ether—electric and magnetic forces would cease to act through space. Even a body not casting light can be a center of electrical action if it radiates heat. Electricity therefore possesses all Nature and even man. The eye itself is, in fact, an electrical organ.

The influence of this new system of physics upon the development of natural science and the manifold applications in practical life of which it is capable can not easily be overrated. Only recently a new application of Hertz's discovery was made by an American, who is trying to develop photographs by the agency of the Hertzian waves, as science has named them—that is, by electricity instead of light. Hertzian waves, Hertzian investigations, apparatus, and methods form henceforth an essential part of all hand and text books of electricity. The facts established by Hertz's experiments have been molded into a mathematical formula by their author, who in this purely theoretical work also has shown himself to be a master of high genius in the realm of abstract science. There is at present in press and will soon be issued by T. A. Barth, at Leipsic, a comprehensive work, Principles of Mechanics in a New Connection, found among his unpublished papers at the death of Prof. Hertz. Its appearance is eagerly watched for by the scientific world.

However highly his own time and posterity may prize the man of science, the great discoverer, in Prof. Hertz, his value as such to the world at large does not surpass that of the rare purity and greatness of his character, of the intrinsic merit which he possessed for those who knew him personally. A world-wide reputation so rapidly attained might have produced in the young man some feeling of elation and pride, and in his colleagues somewhat of envy. But, as Prof. Hubert Ludwig, representing the University of Bonn at Prof. Hertz's funeral in Hamburg, said in his memorial speech:

"The rich harvest of fame and glory which was granted him, and that was so fully merited as not to be tainted by a single breath of envy or jealousy, never caused him to give up one atom of the noble simplicity and genuine modesty which were a fundamental trait of his character. His modesty was a most lovable quality in this great man, asserting itself not only in every-day life, but also in his scientific labors, which it pervades with the endearing charm of an amiable personality. It was coupled with the most considerate indulgence when judging others. His ever-ready recognition of other people's merits made it a sheer impossibility to grudge him his attainments or to be his enemy.

"'None knew him but to love him,
None named him but to praise.'

At the same time he was governed by an inflexible veracity."

He was indeed a most lovable man, and was never happier than in giving pleasure to others. His kindness and benevolence found expression in many ways, most of all toward those above whom he was placed as head of his department in the university. It was a pleasure to notice his satisfaction, when he found it in accordance with his duty, to confer a benefit or favor. And when it was incumbent upon him to refuse or displease, he became the director who performed his duty, and the friend who regretted what had to be done. He was always ready to show hospitality to scientific men who came to Bonn from other parts of Germany or from foreign countries. Even under the restraint of a foreign tongue (he spoke English and French with considerable fluency) his conversation was charming. Not what he had achieved, gave him his ascendency in scientific discourse, but what he, beyond a thousand learned men, could achieve at any time—original and sagacious thoughts, springing up on the spur of the moment, and losing none of their force by being expressed in the most unpretending, simple form. When entertaining friends or conversing with his dear ones, he perfectly forgot the learned professor in himself; he was so much at his ease, so full of fun, that none around him could help sharing his gayety. Many of his guests,

prominent men of science as well as students, will always remember with pleasure and gratitude delightful trips made with Prof. Hertz to the Siebengebirge or evenings of genial intercourse at his house in the Quantiusstrasse at Bonn. Absolutely devoid of any desire to pose before the public, the professor sometimes astonished students newly entered for his lectures by putting in a bit of humor where they had expected abstract instruction; but they soon found themselves none the worse for it. Some simple word, a casual remark made as if it were a self-understood thing, from his lips did more toward improving the mind of his audience than a long lecture from another. He was not a scientist inculcating one special branch of knowledge—he was a thinker. To be considered an authority, even by the youngest beginner, was an idea that never entered his mind. In the congenial atmosphere of advanced classes, new ideas and conceptions seemed to rise in him and flow from his lips as though there could be no easier thing in the world. He was at his very best when propounding a problem to this small circle, showing how he would attack it. None, however capable, but could profit by this teaching; genius itself seemed to prompt it.

With penetrating perspicacity he took hold of his problems. As a veritable disciple of natural science, he strove to accomplish his ideal ends, although by means of theory, which he completely mastered, yet not merely by theory and not for her sake only; what he aimed at first and last was the most accurate establishment of facts. Pervaded as his strong personality was by an absorbing love of his science, the rare harmony of his nature kept him equally from an exaggerated enthusiasm and from prosaic dullness. An uncommonly great number of valuable researches made at the Physical Institute at Bonn during the short time of his leadership prove his rare capacity and untiring eagerness to incite young talents to the best possible application of their faculties and so pave the way for their success in research. But in a wider sense of the word we may call his disciples all those physicists who are at this moment, and will be for a long time, occupied in exploring the provinces which he was the first to open. In this sense almost one quarter of all living physicists call themselves Prof. Hertz's followers.

The honors paid at his funeral to the memory of this young and ardent worker were exceptionally great. He was buried in his native city, Hamburg, where the most widespread sympathy for his family and the deepest regret over his loss were shown. From Bonn, Karlsruhe, and Berlin came friends, colleagues, and students, some of them officially representing their colleges. Universities and prominent men from all parts of our globe have sent messages of esteem and sympathy to the wife, the parents,

and the University of Bonn. It may be questioned whether such utterances of sympathy and respect, much as they tend to make mankind feel itself as one, can offer consolation to those whose bereavement is greater than words are able to convey. However, what Mr. Lowell said in one of his simple and admirable memorial addresses is certainly true:

"It may seem paradox, but the only alleviation of such grief is a sense of the greatness and costliness of the sacrifice that gave birth to it, and this sense is brought home to us by the measure in which others appreciate our loss."

Prof. Hubert Ludwig, of Bonn, uttered the last farewell at the grave of his friend and colleague. He expressed the sentiment of those grieving at his bier in these final words:

"This loss is so great that we are tempted to recall the old saying of the envy of the gods. But in this solemn hour let us resolutely banish such temptation, and instead of rebelling against destiny, let us at the open grave of this God-inspired investigator bow low our heads and hearts before the inscrutable."

The importance of mountaineering from a geographical point of view, as is shown by Mr. Edward Swift Balch, in a paper on Mountain Exploration read before the Geographical Club of Philadelphia, is hardly understood by people in general. How much has been done by mountaineers from a geographical, a scientific, or an artistic impulse is hardly known, and the extent of field still open for mountain exploration and observation is not really appreciated. This field, represented by the mountains and mountain ranges in the five continents and the islands, covers something like one sixth of the globe. The first undoubted ascent of a glacier-bearing peak—that of the Buet, by Jean André and Guillaume de Luc, of Geneva, in 1770—was for the scientific purpose of making some experiments on the atmosphere for Jean André's book, Researches on the Modifications of the Atmosphere. The earliest ascents in central Switzerland were made by monks in the love of geographical exploration; and in the greatest of these monks, Placidus a Spescha, scientific knowledge and a love of mineralogy and geology were added to a desire to know the boundaries and the formation of the mountains with which he was immediately surrounded. Mont Blanc was first ascended, with scientific ends, by the geologist De Saussure. In the record of the contributions of mountaineering to science we have the studies of glacial phenomena and the forms of water in ice and snow and clouds, made with care and trouble by such men as Tyndall, Forbes, Agassiz, Escher von der Linth, and Guyot, who have camped out on some occasions for weeks at a time; and the famous expedition of 1842, when the movements of glaciers were practically first determined, and when the investigators from Neuchâtel lived on the ice for two seasons, under the protecting shelter of a bowlder, which became known as the "Hôtel des Neuchâtelois." The geology of the mountains and their botany and zoölogy have been studied. They have been utilized for astronomical and for weather observations; and the latest important attempt in this line is M. Jannsen's establishment of an observatory on the summit of Mont Blanc.

EDITOR'S TABLE.

THE FOUNDER OF THE POPULAR SCIENCE MONTHLY.

THE readers of this magazine will, we are sure, appreciate the satisfaction with which we have lately hailed the appearance of a biography, done by a most competent hand, of the late Prof. E. L. Youmans. This biography is one which all who were measurably acquainted with the late professor's work in the cause of science felt *must* be given to the world. Many biographies are not much more than tributes to the interest which a man's personal friends take in his character and career; but in the case of the late Prof. Youmans a chapter in the history of the intellectual development of this country would have been missing had his biography not been written. He came at a critical time; he was the man for the crisis; he saw his work, and he did it. That work was preparing the public mind on this side of the Atlantic for the reception of a new order of ideas in science and philosophy, and then transplanting those ideas into the soil so prepared. Prof. Fiske, whose literary skill never appeared to greater advantage than in the production of this biography, quotes a country clergyman as having said to him in 1857, "There is a great intellectual movement going on in Europe of which scarcely anything is known or even suspected in this country." The professor himself adds: "Lyell's great work on geology was published in 1830; a quarter of a century later I do not believe there were five men in our town who had ever heard of 'uniformitarianism'; it was only a very bold spirit that ventured to allude to the earth as more than six thousand years old. Science in general was regarded as a miscellaneous collection of facts and rules, some useful, some curious or even pretty; as for looking upon it as a vast coherent body of truths concerning the universe and its interdependent provinces, few minds, indeed, had grappled with such a conception." As late as the year 1860 one of the most enterprising and liberal publishing houses in Boston declined to republish Spencer's essays on education. "The Americans at that time," says Prof. Fiske again, "were excessively provincial. There was much intellectual eagerness, along with very meager knowledge."

Edward L. Youmans was born in the year 1821. We need not recite any of the incidents of his life, which are given in the most interesting manner by Prof. Fiske, and were also sketched last month in another department of this magazine. What we wish to point out is that, born in what his biographer calls a "provincial" society, he had an intellectual eagerness which was not satisfied with meager knowledge, nor yet with meager scientific conceptions. There was in him a singular and happy union of practicality and philosophic breadth. He was utilitarian in his aims, but he loved a wide expanse for his thoughts. Domestic economy was with him a favorite field of investigation and study, but at another moment he would take the keenest delight in seeing the plowshare of a vigorous criticism ripping up the clods of old philosophical systems. He did not himself claim to be an original investigator—nor does his biographer make the claim for him in any important sense; but he was ever on the watch for some enlargement of human knowledge or some improvement in the instruments of intellectual research. His was a pre-eminently open mind, and he loved science because, though it might have

at any given time its dark corners, there were no corners in it that had to be left dark, the constant effort of the scientific worker, in every portion of the field, being to get light and yet more light. He loved science because in studying it he breathed the air of liberty and became conscious of intellectual growth. No sooner had he emerged from the cloud which a prolonged period of alternately partial and total blindness had cast over his early life, than he betook himself to the lecture platform, and began, as his biographer expresses it, to "interpret science for the people." In this field he accomplished most useful work. Possessing, as he did, a wonderful gift of exposition, and having the kind of mind that naturally seized upon the most instructive and interesting aspects of things, he was able both to charm and to stimulate his audiences in an unusual degree. There was about him, too, a stamp of candor, of liberality, of noble-mindedness that must have exerted a powerful influence for good upon those with whom he came into contact. Science with him was not a trade, it was a vocation; and, obeying at every moment what seemed the highest call, he was ever ready to listen to a higher.

The higher call came with his first serious introduction to the works of Herbert Spencer. Long had he been feeling his way toward some more comprehensive scientific view than any he had yet grasped, seeking, if haply he might find, some common principle of interpretation for the infinitely diverse phenomena of the universe, when an article in a London periodical directed his attention to Spencer's Psychology. The study of this work, which he shortly afterward ordered from England, convinced him, as his biographer has expressed it, that "the theory expounded was a long stride in the direction of a general theory of evolution." His interest in Spencer was strengthened by a perusal of his Social Statics and of the valuable articles he was contributing at the time to the English quarterlies, particularly the Westminster Review. The biography tells how, when he found that Spencer had issued a programme or syllabus of his proposed system of philosophy, and was soliciting subscriptions thereto, Mr. Youmans wrote to him, expressing indebtedness for the advantage he had derived from the study of what he had already written, and offering any assistance which it might be in his power to render toward the success of the forthcoming volumes. Thus was the foundation laid of one of the most honorable, interesting, and fruitful friendships of which our times possess any record. On the one side, ardent and enthusiastic devotion to an intellectual leader whose teaching was looked upon as a message of transcendent importance to the present generation; on the other, a quick and generous appreciation of that devotion and of all the practical service to which it led. Those who have not yet read the biography, and may wish to see in what ample terms Spencer acknowledged the disinterested labors of Prof. Youmans in his behalf, can not do better than turn to the book and read Spencer's letters. It was certainly the opinion of the great English philosopher that Prof. Youmans, by his energy and zeal, his tact and persuasiveness and business sagacity, almost created a public for him in America; and, by the help and encouragement thus afforded, greatly contributed to the success of his works in England.

Having adopted Spencer as his leader, Youmans never faltered in his allegiance to him. It was a case of loyal following, not of blind partisanship; if any fuller light had shone into our late friend's mind, he could not have turned away from it; for that to which he was supremely loyal was the truth. But, in point of fact, he never saw anything else in the guise of philosophy which seemed to him to possess half the merit or value for mankind that he discovered

in the theory of evolution, as expounded by Spencer, and coupled by him with a strong assertion of the rights of the individual. Evolution as a world-grasping hypothesis, and "the law of equal liberty" as the charter of individual rights, made an absolutely irresistible appeal to the deepest instincts of the late Professor's nature; and it is no wonder, therefore, that in them he found an abiding anchorage.

We need only mention, in passing, the important work done by Prof. Youmans in arranging for the publication of the International Scientific Series, of which over seventy volumes have now been issued; but it is fitting that we should speak a little more fully on the subject of his establishment of The Popular Science Monthly. Even before he became interested in Spencer he felt that there was a great need in this country for a periodical which should be devoted to popularizing, not so much the results, as the methods of science. He was too much of a philosopher ever to forget that what the people want, far more than a diet of facts, is education in correct thinking, in the right use of their intellectual faculties. He fully believed, with Spencer, that natural science affords incomparably the best means of discipline for the mind; and after he had become impressed with the importance of that writer's general scheme of thought, he was more than ever desirous of establishing a magazine that might help in the propagation of sound scientific views. How suddenly in the end The Popular Science Monthly sprang into existence, the biography will tell; and on what sound lines it was drawn may be judged from the fact that in the course of twenty-two years those lines have never been departed from. The Popular Science Monthly is to-day what it was in the first year of its existence, and what its name imports. It is not intended for specialists, though specialists have made many valuable contributions to its columns. It aims to bring before intelligent readers the best and most interesting results of contemporary scientific activity, and to keep science as a power, as a method, as an inspiration, as the ally of humanity in its warfare against evil, prominently before the public mind. The magazine has had its own battles to fight, and, in its earlier years particularly, a good deal of misrepresentation to encounter. It has been accused of hostility to particular modes of belief, simply because it has wished to open paths of independent investigation in all subjects. It has, however, outlived most of the prejudice that at one time it excited, and to-day is welcomed in every part of the country as one of the most useful of educational agents, as affording just that aid to sound living and right thinking which it was the most earnest desire of its founder that it should afford.

To some it has appeared that the Monthly set too small value on literary culture, and that its late director was too contemptuous in his attitude toward classical studies. In all questions of this kind, however, a time element enters. Twenty odd years ago it was hard work to get any kind of proper recognition for science in schemes of education; and many sophisms that have since been exploded as to the necessity of the study of the classics for the formation of a good literary style, or for the right discrimination of words, or even for the proper development of the logical faculties, were then widely current and aggressively asserted. It was necessary, therefore, for a periodical that had been started with the express object of championing the claims of science, to put its own case as strongly as possible, and attack with vigor what it considered the errors of the older educational systems. If sometimes it pushed its criticisms too far, that is only what happens when any warfare is being keenly waged. That the founder of the Monthly was no enemy of culture in the widest sense, all who

were acquainted with him are well aware. In his youth he read even more of literature than of science. He had no acquaintance with the Greek or Latin classics in the original, but he read the best of them in translations, and with much enjoyment. His own literary style was a standing refutation of the plea that, in order to write good English, a man had to become familiar with Greek and Latin. It had the three great merits of accuracy, amplitude, and balance, and at times was even impressively eloquent.

Prof. Fiske has given a faithful presentation of the man, and it is not our purpose to add anything to his words of eulogy. Of no man can it be more truly said that his influence survives him. As the biography makes plain, he had a rare combination of qualities intellectual and moral, and he has laid an enduring impress, not only on the magazine which he founded, but on multitudes of minds with which he came into contact. The reason why he accomplished so much and wielded so great an influence may be found, we believe, in that disinterestedness which was one of his most conspicuous qualities. He was a true apostle, because he thought more of his cause than of himself. Had he thought more of himself, he might have been with us to-day; but who shall blame enthusiasm and devotion such as his? It led to oversight in matters pertaining to health, and that is to be regretted; but it stamped the man as one of the working, fighting heroes of the nineteenth century, and as such this generation will honor his memory.

LITERARY NOTICES.

The Mummy. Chapters on Egyptian Funeral Archæology. By E. A. Wallis Budge. With Eighty-eight Illustrations. New York: Macmillan & Co. Pp. 404. Price, $3.25.

The author of this work is acting assistant keeper in the Department of Egyptian and Assyrian Antiquities in the British Museum. The matter of it was originally written to form the introduction to the catalogue of the Egyptian collection in the Fitzwilliam Museum, Cambridge, and was intended to supply the information necessary for understanding the object and use of the antiquities described therein. It is hoped that it may likewise be of service to all persons interested in the antiquities of Egypt. It embodies the information which the experience gained from several years of service in the British Museum has shown to be the most needed by those who, though possessing no special knowledge of Egyptian antiquities, are yet greatly interested in them, or who have formed, or are about to form, Egyptian collections. Following up the idea that the mummy was the most important of all objects to the Egyptian, accounts are given of the various methods of embalming; of the amulets and other objects which formed the mummy's dress; of the various kinds of coffins and sarcophagi in which he was laid; and also of the most important classes of tombs hewn or built in different dynasties. These accounts are preceded by a satisfactory sketch of Egyptian history, with a list of the dynasties and of the cartouches of the principal kings, a list of the names, a chapter on Egyptian methods of writing, the Rosetta stone, etc., and are followed by descriptions of mummies, of animals, reptiles, birds, and fishes, and information concerning Egyptian months, Egyptian and Coptic numbers, and lists of common hieroglyphic characters and common determinatives. In a short space the book tells much about Egypt in a wholly acceptable way, and it may be regarded as one of the very best of the popular works on the subject.

The Journal of Physiology. Edited in Coöperation with Professors W. Rutherford, J. Burdon Sanderson, and E. A. Schäfer, in England; H. P. Bowditch, H. Newell Martin, H. C. Wood, and H. H. Chittenden, in America; and T. F. A. Stuart, in Australia, by Michael Foster, M. D. Vols. XIV and XV. 1893. Cambridge Engraving Company, England. Price, $5 a volume.

This is the leading journal of original physiological research in the English language, and is devoted to the recording and illustration of the investigations of the most

eminent experimental physiologists of English-speaking countries. The two volumes contain more than thirty articles, with full details and graphical records of experiments continued in series and their results, relating to the nerves and nervous action, the heart, circulation, muscular work, digestion, the kidneys, animal temperatures, the secretions, mechanical action of the organs, chemical changes in the body and in its secretions, etc., and the chemical effects of various agents, action of drugs, salts, and other substances on various organs and their work, the senses and sensation, and other bodily functions and processes. The journal is a work of immense value to students and all interested in investigations in this field of research, and in the application of their results to the promotion of the health and vigor of the body and the lengthening of life.

The Alchemical Essence and the Chemical Element: An Episode in the Quest of the Unchanging. By M. M. Pattison Muir. London and New York: Longmans, Green & Co. Pp. 94. Price, $1.50.

The essence in old-time alchemistry, when contrasted with the element of the modern cult, can scarcely fail to excite an interest bordering on romance while retaining bounds strictly scientific in their nature.

The terse and entirely explicit volume before us presents the acceptable feature of uniting more closely some turning points between our acquaintance with modern chemistry and the visionary ground occupied by our forefathers, who long sought the unity of Nature in the—as yet—unfound philosopher's stone. When Thomas Vaughan, under the *nom de plume* of Eugenius Philalethes, wrote in the seventeenth century that Nature did not move "by the theorie of men, but by their practice," he pointedly foreshadowed and it mayhap unconsciously prophesied the achievements of modern chemical science. In this, as in numerous other phenomena, an inexorable though unseen law seems to wait upon all sincere effort to unbosom the secrets of Nature. When the anxious alchemist of a bygone age immersed his bar of iron in a solution of bluestone and, obtaining a deposit of copper upon the iron surface, announced that he had transformed the latter into the former metal, he mistook a seeming for an absolute truth; or, when in boiling water he discovered a residue of earth, and declared that he had changed water into mud, he simply lacked the instrumental means—the balance—to verify a whole instead of pronouncing a half truth. By such an experimenter, strange occurrences were not patiently dealt with, and a discovery was labeled prior to its meaning being known. A lack of delicate philosophical instruments retarded the advances of the alchemist at every step, and that he made any progress at all was mainly due to his incessant day and midnight vigils.

While the author of this entertaining volume records with care material facts governing ancient as well as modern chemistry, he admits the indefiniteness of the conception of unity in material phenomena, and intimates that, to at all come within reach of a definition of Nature's underlying essence, would be to know every detail of natural science, and indite a history of Nature itself. His essay is penned "in the hope" that such as exert their "wit and reason" regarding life's problems may help to solve Nature's questions and "those of her students who follow the quest of the unchanging."

Pain: Its Neuro-pathological, Diagnostic, Medico-legal, and Neuro-therapeutic Relations. Illustrated. By J. Leonard Corning, A. M., M. D. Philadelphia: J. B. Lippincott Company. Pp. 328. Price, $1.75.

To advance in some degree "the cause" of medical science is the sincere desire of the author in placing in the hands of students and physicians the above work, which to all intents and purposes bears upon its face the insignia of much thought and labor. In no special branch of medical treatment is the practicing physician more frequently called upon to exercise his wits than where pain is concerned, and for its alleviation the accurate diagnosis needed.

The book is divided into two parts; the first embracing pain in its physiological, pathological, and clinical relations. These are again subdivided into a definition, conduction, and physiology of pain. In treating of the pathology of pain no effort is spared to render lucid neuritis, or inflammation of the nerves, multiple neuritis,

chronic alcoholic neuritis, that of consecutive influenza, of beriberi, and the neuritis of leprosy. Under definite nerve areas, neuralgia is dealt with exhaustively and at length; also, rheumatic and gouty diatheses and the pains engendered thereby. Under Chapter VI, the diagnostic value of pain, as it deserves, receives that effective treatment so characteristic throughout the book of the author's predominant bent of mind.

Part II of the work takes up the special therapeutics of pain, and points to the importance of rest in the treatment of nervous symptoms engendered by prolonged and severe pain. Apart from the internal remedies directly or indirectly applicable in treating pain, the author proceeds to unfold his own methods in increasing the certainty and duration of several remedies and their action on the peripheral nerves, and goes on to expatiate upon the various surgical expedients not infrequently employed. The uses of compressed air in conjunction with remedies which tend to diminish the acuity of perception, including author's pain, come in for their quota of recorded observation, while prevention of relapse is noted fully and with precision. The closing pages supply some supplementary observations on torture and the infliction of pain as a judicial punishment during the middle ages in Europe.

Though cases that more properly belong to the domain of general surgery and medicine are not discussed by the author, the intricacy of the whole subject of pain is never lost sight of, and the vast array of pathological conditions treated assumes a character unquestionably of interest and high utility to the medical world.

A Student's Text-Book of Botany. By Sydney H. Vines. (First half.) New York: Macmillan & Co. Pp. 430. Price, $2.

This text-book has grown out of the author's labors in revising Prof. Prantl's *Lehrbuch der Botanik*, when the thought of extending the scope of that work was suggested. The extension went on till what is essentially a new and distinct work was produced. It deserves commendation for its thoroughness and the symmetry of its structure. The first part, now before us, is devoted to the exposition of morphology, a brief chapter on classification, and a description of the cryptogams. The province of morphology is defined to be "the study of the form of the body of plants, including the development of the body, the segmentation of the body into members, and the form and mutual relations of the members, as also the intimate structure (anatomy and histology of the body and its members in so far as structure throws light upon the morphology of any part of the body). It is an essentially comparative study." The two systems of classification—natural and artificial—having been distinguished, the natural system is defined as having for its object the classification of plants according to their fundamental relationships; and these being established once for all by Nature herself, it is not based on any arbitrary principle, but depends upon the state of our knowledge of these fundamental relationships. "These find their chief expression in the structure and other characteristics of the reproductive organs, as well as in the peculiarities of polymorphism presented by the life-history. This is more definitely true with regard to the definition of the larger groups of the vegetable kingdom; within these groups relationships may be exhibited sometimes in one way and sometimes in another, so that it is not possible to lay down any universal rules for determining close affinities. As the investigation of this subject is far from being complete, the natural system can not be regarded as being perfectly evolved; the various general sketches which have hitherto been given are therefore no more than approximations to the truth."

Man an Organic Community. By John H. King. London: Williams & Norgate. New York: G. P. Putnam's Sons. Two vols. Pp. 327 + 328. Price, $4.50.

We have here an effective work involving issues of prime import, as "an exposition of the law that the human personality in all its phases of evolution, both co-ordinate and discordinate, is the multiple of many sub-personalities." In each successive chapter the reader will discover clear conceptions fairly elaborated, and designed to prove the initial allegation which the author superadds to a law already recognized in the domain of science treated. By progressive

steps we are led to the pivotal idea through a radius of reasonings, from the simpler to the more complex forms constituting the human personality. Through this process the attempt is apparent to keep in a measure abreast of modern scientific research, and supply a truer interpretation of the meaning of human life. This, in turn, necessarily involves an ethical significance, not so much aimed at by the author as connoted by the reader in his perusal. Throughout the whole field of view selected, suggestions occur which mark a decided modification in, if not an entire elimination of, the popularly accepted idea of man's individual existence *in duo*. Withal, facts and ideas are so grouped as not to identify polemics with the object to be attained.

Among the more familiar doctrines treated of is that the real relations of things are not necessarily elucidated by, nor do they at all times express, their apparent conditions, more particularly so in the domain of natural phenomena. The belief in the homogeneity of man's personality received its primal shock and break when the differentiation of body and soul became an authorized concept in the past. Then, for the first, we discover a distinct personality expressed as attaching to the two entities. Organism and spirit had their distinguishing features and their separate functions, whether in union or disjoined. As with the mental attributes and moral affinities, any one of which might undergo change or be absolutely lost—as in numerous cases of insanity—so, though not in so marked a degree, a process distinct in character, supervenes the necessary changes which accompany growth outputs in the human organism, either marking secedence to senility, or the progressive steps to maturity. The human system, therefore, is no longer the self-contained individual, but each group of living activities within it has its special range of duties and relations, even down to the germ with its individualized potencies, which we discover only narrowly removed from the plasma. Hence we find in the human organic co-ordination, "not only the ruling and working subpersonalities of an individual character," but "the associate actions of combined and representative personalities the same as in a state; and, as in a state one personality may be attached to another as a check, so diverse organic attributes check other organic attributes and regulate the general equipoise by their varied interactions. As with the organic, so with the mental attributes."

Starting with the assumption that co-ordination, or growth combination, constitutes the governing principle of the human personality differentiated under distinct subpersonalities, the author proceeds to show that these latter in their content are but aggregates of a still lower class of differentiations. From the nomad to the man, this principle characterizes all growths. Further, while life exists these organic co-ordinations may separate or blend, and tissues are found to degenerate or advance, to be repellent or to severally work in unison. In each and every occurring and recurring complexity, however, the earlier differentiations which marked individual changes are never wholly forfeited; in brief, the evolutionary principle remains intact.

In Book I of the first volume we have inclusive the nature and origin of the human personality, the phylogenic stages of growth, the phylogenic sexual forms, and the co-ordination of faculties and functions. The forms of mental and organic co-ordination are covered by the second book under three classes and several chapters, all of which are written with a succinctness that sensibly diminishes the reader's labor, and include under "normal forms of co-ordination" the active wakeful state, quiescent repose, the state of reverie, somnambulism, and the induced mental and physical states. We gather from the "forms of co-ordinate variation" the law of variability in human personality, variations resulting from transference and variations through growth. From a review of the abnormal discordinate states, including physical abnormals and discordinations mental and organic, we are introduced to the second volume. This deals mainly with reversions to the lower civilized states, the semicivilized and barbaric states, the state of savages, and finally animal consciousness. Here the third and last book induces reflection on the internal and external relations of man, the modes of self-government in the co-ordinate personality, which betimes becomes alternate and multiple, and the power of self and external suggestion. In a lucid appendix,

wherein the unsolved problems of life are dealt with, we are led to a clearer apprehension of what we do not, rather than what we do know concerning the insoluble. This, in the light of certain—to compound a term—scio-dogmatic allegations extant, is at least refreshing, if not entirely novel.

Legends of the Micmacs. By the Rev. Silas Tertius Rand. Wellesley Philological Publications. New York: Longmans, Green & Co. Pp. 452.

These legends, which are published under the direction of the Department of Comparative Philology of Wellesley College, were collected by Dr. Rand during the forty years of his service as a missionary among the Nova Scotia Indians from whom they are derived. The stories were related to him in Micmac, by the native Indians, and were then translated and written down by him in English. The original manuscript is a volume of nine hundred quarto pages. A few of the legends have already been published—in the Dominion Monthly and the American Antiquarian; and some have been used and cited from in Mr. Leland's Algonkin Legends and in Mr. William Elder's article in the North American Review on the Aborigines of Nova Scotia. Dr. Rand is quoted as saying, concerning the origin of these stories and their relationship to European tales and myths: "I have never found more than five or six Indians who could relate these queer stories; and most if not all of these are now gone. Who their original author was, or how old they are, we have no means of knowing. Some of them are evidently of modern date, because they refer to events that have taken place since the advent of the whites. Some of them are so similar to some of the old European 'fairy tales' and 'wizard stories' in our English story books as to lead to the impression that they are really one and the same." Mr. Leland has noticed some curious coincidences between the Norse myths and those of the Wabanaki or northeastern Algonkins, to which branch the Micmacs belong, and inclines toward an explanation of the resemblances by the theory of direct transmission. Dr. Rand's biographer gives him the credit of being the discoverer of Glooscap, a mythological character which Mr. Leland calls "the most Aryan-like of any ever evolved from a savage mind," and with having saved from oblivion the mythological lore of a people that are losing with every generation their hold on customs and manners. Prof. Horsford, of Wellesley College, took a great interest in the publication of this work; and the editing of it for publication has been done by Helen L. Webster.

Alternating Currents: An Analytical and Graphical Treatment for Students and Engineers. By Frederick Bedell, Ph. D., and Albert Cushing Crehore, Ph. D. New York: The W. J. Johnson Company (Limited), 41 Park Row. Pp. 325.

As precluding the necessity for further search after a certain class of handbooks on alternating currents the present work, designed to answer any query from the simplest to the most complex, will amply repay a careful perusal. A thousand and one interesting comparisons recur within its pages, and it abounds with easy solutions to technical problems. It is a consistent application of the modern method of solving things easily, and many of our educational series are wisely adopting a similar course. As the authors suggest, the principles underlying the subject need clear elucidation, more particularly as incessant advances in the utilization of alternating currents and the apparatus employed are, and with pronounced effect, hourly coming to the front. The comparative newness of the theory regarding these currents has attracted the attention of electrical engineers from all quarters, so that any problem one might select has already been fully treated by known writers. Still, nearly the whole bulk of solutions extant, apply in most instances to special cases. From this fact has arisen the desire to have the subject treated generally.

The work is divided into two parts. The first is entirely analytical in its nature, and the second is mainly graphical. Circuits involving resistance and self-induction are minutely considered, and the elementary principles establishing the equation of energy are dealt with as founded upon the experiments of Faraday, Coulomb, Ohm, and Joule. From this it is manifest that no previous knowledge of electricity or magnetism is necessary in order to grasp the solutions

given. Throughout the second part the same order prevails as obtains in the first, and the treatment of problems concerning simple circuits embracing self-induction and resistance is extended to the like, as involve combination circuits and their phenomena. Then such problems are treated as include simple and combination circuits having capacity and resistance, but void of self-induction. Also, such circuits as contain capacity, resistance, and self-induction, together with combined and parallel circuits.

The present is a second edition of the work, on which much care has been bestowed with the view of eliminating errors that unavoidably crept into the first issue. Toward the close of the first part some intensely interesting and instructive paragraphs occur on wave propagation in closed circuits, showing the vanishing attitude of positive and negative waves and the resulting effect, the potential zero at middle point in the cable, and proving that the expression for potential may be simplified if the cable's length should happen to be a multiple of wave lengths. The structure of the volume is admirably suited to students, as any problem needed may be readily found.

Art in Theory: An Introduction to the Study of Comparative Æsthetics. By George Lansing Raymond, L. H. D. New York: G. P. Putnam's Sons. Pp. 266. Price, $1.75.

The essential idea, if not the sole aim of this volume, is the application of the term *representative* to all art forms, whether of word or deed; the representativeness to include more than the limitations hitherto placed upon it by certain English art critics, and such as make a further distinction between what they term presentative and representative art. Indeed, the author's effort is entirely legitimate, and scores an advance upon the many imitative if not conventional so-called art criticisms extant. It is invariably refreshing to encounter any original subtlety of sense attaching to a new or augmenting an old idea, and in Prof. Raymond's book the true art of judging "Art in Theory" is not lacking. As the author intimates, works of art are the products which reveal the methods of the artist, whether he desires to represent a thought or a thing—to produce effects of any kind whatsoever. A courageous and justifiable departure on the part of Prof. Raymond is, where he breaks away from the historico-critical method of regarding art and its influence as an æsthetic factor. Duly crediting historic criticism, however, for its inestimable services in all other departments, he goes on to show that as the arts are affected by laws of development, more especially the higher arts, these latter are very often distinctly not expressive of the spirit of the age. Precisely, and for the unfortunate reason that conventionalism controls them. The historian claims what is not true when he alleges that all art is deserving of study. To the artist as an artist it is not. That art which has attained a high level of excellence is of interest to him, and very often to him alone. Hence, the great artists' methods are not infrequently misinterpreted in their day. The æsthetic power that distinguished the work of an Aristotle, a Confucius, an Angelo, or Shakespeare had not its immediate influence for the now manifest reason that they were moved as much, at least, by the spirit interpreting within them as by the conventionalities that made demands from without.

Whether we contemplate one or more of the twenty brilliant chapters within this volume, involving either the significance of form in art, classicism and romanticism, the art-impulse, taste, theories concerning beauty, or any one of the many features so pregnant with suggestion we feel assured that readers will acknowledge their introduction to an author not bound by mental servitude.

An Examination of Weismannism. By G. J. Romanes, M. A., LL. D., F. R. S. Chicago: The Open Court Publishing Co. Pp. 221. Price, $1.

The object of this volume is tersely stated in the author's words—to separate the grain of good science from the chaff of bad speculation. This winnowing process, when closely followed, proves to be highly interesting. Dr. Romanes gauges his separator to meet Weismann's great doctrines of the *perpetual continuity* and *unalterable stability* of germ-plasm, and when at last, with relentless logic, he has sifted out every extraneous speculation, and holds these theories in his grasp to demolish them, the wise and wary Weismann

announces that upon further investigation he believes that germ-plasm is *universally unstable!*

When this recantation occurred, Dr. Romanes considered for a while whether he should cancel the first two chapters of this book already prepared for publication. He concluded, however, to let them stand, justly observing: "It is open to question whether an author of any kind should suffer an elaborate system of theories to be published and translated at the very time when he is himself engaged in producing another work showing the untenable character of their basal premises. . . . At the least he should have added notes to his Polar Bodies and Amphimixis to let the reader know his change of doctrine."

It might be supposed when these leading features were stricken out from Prof. Weismann's theories of descent and evolution, the remainder would be characterless. But the fanciful mechanism of heredity was retained, the difference in mortality between the Metazoa and Protozoa was emphasized, and the instability of germ-plasm was confined to the least possible degree, still making amphimixis the main cause of variation. This disturbed Dr. Romanes more than all else. He chafed at "a germ-plasm that is both stable and unstable at the same time," and writes, "It is this half-turn to which I object, as unwarranted in logic and opposed to fact."

The subject of the inheritance of acquired characters, associated with the name of Weismann, is not taken up by the author of this dissertation, except incidentally, but is reserved for a future volume, when it will be discussed as a matter of fact. The major part of the book is devoted to a consideration of Weismann's theories in comparison with the hypotheses of Darwin and Galton.

According to Darwin the substance of heredity, *gemmules*, may be formed anew in each generation; is discontinuous, and proceeds from the somatic to the germ cells, i. e., centripetally, whence the inheritance of acquired characters is habitual.

With Galton the substance of heredity, *stirp*, is mainly continuous; proceeds from germ cells outward to somatic cells, or centrifugally. Acquired characters are rarely inherited.

Weismann taught that the substance of heredity, *germ-plasm*, was perpetually continuous; proceeded from germ cells to somatic cells, centrifugally. Acquired characters can not be inherited.

With the modifications recently made, this theory substantially coincides with Galton's. Originally, Weismann held that the sphere of germ-plasm was entirely restricted and localized; that there was no reciprocal action between it and body substance; but afterward, upon being confronted with the botanic phenomena involved in cutting, budding, and graft-hybridization, he allowed that germ-plasm might be found in the nuclei of somatic cells, diffused in the cellular tissue of plants.

Wrapped up also in the tenet of unalterable stability was the origin of hereditary individual variation, which was thus referred to the Protozoa, amphimixis being the only possible cause of congenital variation among multicellular organisms.

In the germ-plasm these dogmas were molted as follows: "The cause of hereditary variation must lie deeper than this. It must be due to the direct effects of external influence on the biophores and determinants; . . . the *origin of a variation* is equally independent of selection and amphimixis, and is due to the constant occurrence of slight inequalities of nutrition in the germ-plasm."

These sentences, which undo so much of Weismann's distinctive theories, were, according to Dr. Romanes, unnoticed by most of his critics. It may be added that the differentiation of doctrine is thus reduced to *centripetal heredity*, Galton and Weismann; *centrifugal heredity*, Darwin and Spencer.

Weismann's mechanism is extremely elaborate, including nine circles of germ-plasm: molecules, biophores, determinants, ids, idants, idioplasm, somatic idioplasm, morphoplasm, and apical plasm. Of these hypothetical divisions Dr. Romanes would adopt the ids and determinants, since it is a group of cells rather than a single cell that varies in descent.

Two appendices are added to the book. The first contains an argument as to whether a centrifugal theory, germ-plasm, is more conceivable than a centripetal one, pangenesis. Dr. Romanes concludes that one is no more imaginable than the other; "that, whatever the mechanism of heredity may be, it is at

once so minute and complex that its action is inconceivable." Appendix II is devoted to a discussion of telegony, much of which has appeared in this magazine. Dr. Romanes believes in centripetal heredity, and therefore can not agree with Mr. Spencer, whose theory is of the centrifugal order.

Electric Waves: Being Researches on the Propagation of Electric Action with Finite Velocity through Space. By Dr. Heinrich Hertz. London and New York: Macmillan & Co. Pp. xv + 278. Price, $2.50.

The impossibility of reviewing in brief a work of such transcendent importance to electrical science as this volume undoubtedly is, will become apparent to the reader when we declare that the progress—exclusive of the author's own discoveries—so concisely recounted, not only embraces the names and experiments of and from Newton and Bernoulli and their day, down through a line of seventy-five prominent men of genius, but also includes with Faraday and Ampère—of late years—Helmholtz, Lodge, Maxwell, Siemens, and Sir W. Thomson in our own day. The volume before us is the authorized English translation from the German work, by Prof. D. E. Jones, B. Sc., and includes an able preface by Lord Kelvin, President of the Royal Society.

Dr. Hertz was primarily induced to carry out the experiments elucidated in this volume through the proffered prize in 1879 of the Berlin Academy of Science, for a solution of the problem to establish by experiments "any relation between electromagnetic forces and the dielectric polarization of insulators," which simply meant that a force electromagnetic in itself might be exerted in non-conductors by polarizations, or that electromagnetic induction is the cause of the polarization of a non-conductor. The attention of the professor was first drawn to the problem by Herr von Helmholtz, who promised the assistance of the Physical Institute in Berlin if Dr. Hertz determined upon making the research and necessary experimentation. After many failures, and his first abandonment of the solution, he finally gives to the world the impressive deductions of the original papers—now in the form of fourteen chapters—contributed to Wiedemann's Annalen. These are, in the present volume, supplemented by an ample introduction and various explanatory notes of vast import. Proceeding from the introduction, which emphasizes the experimental and theoretical phases of the subject, we gather from chapter to chapter the crowning results embodied in such phenomena as rapid electric oscillations, the effect of ultraviolet light upon the electric discharge, the action of rectilinear electric oscillations upon a neighboring circuit, the finite velocity of propagation of electromagnetic actions, electric radiation, the fundamental equations of electromagnetics for bodies at rest, and other all-important subdivisions. The work in the aggregate represents the fervid expression of a scientific explorer, whose heart was indubitably in his work, and who now presents us at minimum cost a wealth of labor and a store of new knowledge.

Romance of the Insect World. By L. N. Badenoch. New York: Macmillan & Co. Pp. 341. Price, $1.25.

This volume contains one of the best efforts that have been made recently to put scientific facts into an attractive form. If one can be interested at all in the wonderful ways of insects, this book will spur to better acquaintance. Valuable data have been culled from every quarter, not neglecting the investigations of our American naturalists, Dr. McCook, Mrs. Treat, and the Peckhams. These are grouped under the four topics of metamorphoses of insects, their food, home-building, and defenses.

The transformations of insects, although seemingly abrupt transitions, are but progressive stages toward maturity, mainly due to the nature of an insect's skin, which does not permit enlargement of form.

The bill of fare relished by insects exceeds in variety that demanded by the larger members of the animal kingdom. Anything from a nettle to a fungus may be acceptable, horn, cork, or grease being the favored diet of some species. There is also a long list of insects that are parasitic, and others who breed their own cattle.

Among those who build hermit homes are described the mining, carpenter, and mason bees; the wasps, making nests of clay; the gall-makers; the lictor moths that carry their curious dwellings about with them, and the

ingenious spiders who build trapdoors and turrets. Social homes are those of the mason, carpenter, and leaf-cutting ants; of the wasps manufacturing paper and cardboard, including the Nectarinia that construct globular nests with a spiral flight of stairs.

Thousands of insects possess no other defense than their protective resemblances. Other classes decoy their prey by simulating some alluring object. Under the head of variation of color some account is given of the experiments in regard to larval susceptibility. Brightly colored insects find protection in a nauseous taste or smell, irritating hairs or spines, the power to discharge a noxious fluid or inflict a sting. Insects otherwise defenseless escape their foes by mimicry of the behavior and appearance of distasteful species. This curious phase of insect life is considered at some length in the closing chapter.

The book is well illustrated, and contains both glossary and index.

Darwin and Hegel: with Other Philosophical Studies. By David G. Ritchie, M. A. London: Swan, Sonnenschein & Co. New York: Macmillan & Co. Pp. 285. Price, $1.50.

The results of the reasonings submitted in the nine essays constituting this volume may be regarded as having arisen from a judicious survey of the branches of philosophy treated. That on Darwin and Hegel, as the author explains, has been selected as the title of the work, because it emphasizes more particularly the especial point of view, or basic relations which form a juncture in the criticisms under consideration. This is certainly the pivotal essay as tending to reconcile a measured acceptance of the "general principles" arising out of Kantian criticism which governs that idealist philosophy originating with Plato and Aristotle, with an acceptation in the fullest of the intellectual advances made by, residing in, and betimes overlying the historical method of treating institutions and ideas; as well as the theory of natural selection and its logical outcome.

The papers now published in bulk originally appeared in Mind, are recorded in the Proceedings of the Aristotelian Society, The Annals of the American Academy of Political and Social Science, and other periodicals. Regard this book in whatever light acknowledged scientific data may shed, evidence is not lacking of Mr. Ritchie's logical acumen, linked with a genuine spirit of inquiry. In the general presentation of the author's position, these essays, if only cursorily read, might seem totally isolated, whereas a careful perusal reveals a well connected thought undercurrent. The true worth of the volume is best attested by the number of considerations posited in the form of queries, not a few of which are solved outright in Mr. Ritchie's own way, while others remain to be determined by the reader or the future philosopher. Besides the main essay, forming the title, we have one on Origin and Validity, which involves a briefer paper on Heredity as a Factor in Knowledge. The others following are, What is Reality? On Plato's Phædo; What are Economic Laws? Locke's Theory of Property; The Social Contract Theory; On the Conception of Sovereignty, and the Rights of Minorities.

In his analysis of the philosophies of Darwin and Hegel, as applied in their social and scientific bearings, the author intimates that while materialism and idealism are ordinarily referred to as philosophically antagonistic, he nevertheless endeavors to prove that a certain "form of idealism" is not at all incompatible with that monism of materialistic teaching which has nowadays become "the working hypothesis of every scientific explorer." To Mr. Ritchie the monism of materialism alone seems false when posited as an absolute philosophy of the universe. From this he is forced to infer that any such doctrine will necessarily put out of sight conditions of knowledge which true philosophy must not ignore, though the special sciences may. In the paper on Origin and Validity as applied to philosophy, the cords that bind a certain class of popular dogmas presumed to determine real worth Mr. Ritchie severs with relentless logic, and then proceeds with marked caution to distinguish between the philosophical problem and that of psychology and history. Dilating upon what he considers most permanent in Kant's Critical Philosophy, he proposes to examine the relation existing between speculative metaphysics and Kant's theory of knowledge, and supplies not a few illustrations of the import attaching to the distin-

guishment in logic of questions of origin and validity. The difference between reality as understood in ordinary belief, and as the term is applied to science, is very definitely dealt with in the essay on What is Reality? also the query as to whether our feelings are more than our thoughts, and if space is actually occupied by the real. On the Phædo of Plato, the most interesting of the critical examinations apply to the distinction that ought to obtain between Plato's teachings as understood by himself, and as they are subsequently developed and interpreted by Aristotle. Comparing the arguments of the Phædrus with those of the Phædo, some technical points arise in the mind which Mr. Ritchie deems worthy of especial comment. Some striking objections to the position of Economics considered in its relation to the sciences are concisely recounted, and in Locke's Theory—property—the author suggests an interesting study on the theories of Hobbes and Locke in the light of events current in their day.

When the work is considered as a factor in modern research, each page and paragraph may be regarded as a brief historical and critical key to a few of the most striking questions engaging students of evolutionary philosophy.

Dictionary of the Active Principles of Plants; Alkaloids; Bitter Principles; Glucosides: Their Sources, Nature, and Chemical Characteristics, with Tabular Summary, Classification of Reactions, and Full Botanical and General Indexes. By Charles E. Sohn, F. I. C., F. C. S. London: Ballière, Tindall & Cox. Philadelphia: J. B. Lippincott Company, 1894. Pp. vii + 194. Price, $3.

The present work treats of nearly six hundred alkaloids, glucosides, and bitter principles, and it has been prepared in order that the details relating to these substances, now more or less scattered through chemical literature, should be so tabulated that not only a given attribute of any substance shall be readily found, but that there shall be information indicating wherein such a substance differs from, or resembles, another of its class.

The work is arranged in three parts: The first groups together the constituents of one plant or of a number of botanically or chemically allied plants, following as far as possible an alphabetical order. The second part consists of a tabular summary designed for ready reference as well as for contrasting one compound with another for analytical purposes. The third part is a classification of reactions for the special use of analysts.

There is a complete botanical as well as a general index to the volume. It is likely to prove a convenient work for the pharmacologist as well as the chemist.

A Treatise on Elementary Hydrostatics has been prepared by *John A. Greaves* (Macmillan & Co., New York, $1.10) with the purpose of treating the subject as fully as possible without using the calculus; but alternative proofs have been given where the calculus enables us either to obtain the results more easily or to express them more concisely. Having shown that solids may be classified according to their behavior under the action of forces, the author deduces the definition of a fluid from the characteristic behavior of all substances which we recognize as fluids. The special chapter headings are the Properties of Fluids, General Theories relating to Pressure, Center of Pressure, Floating Bodies, The Determination of Specific Gravity, Gases, Hydrostatic Machines, and Capillarity. In the last chapter it is shown from experiments that the energy of a material system depends partly on the extent of the surfaces separating the different substances. On the assumption of the existence of this surface energy, several well-known capillary phenomena are deduced.

For some time past it has seemed to *G. A. T. Middleton* that a concise work upon land surveying, in which modern instruments and modern methods of working were described, would be welcomed by many. The result has been the production of a small volume on *Surveying and Surveying Instruments* (Macmillan & Co., New York, $1.25), the substance of which has already appeared in a technical journal. It includes chapters on Surveys with Chain only, Obstructions in Chain-line and Right-angle Instruments, The Uses of the Level, Various Forms of Level and their Adjustments, The Uses of Angle-measuring Instruments, The Theodolite and other Angle-measuring Instruments, and Instruments for ascertaining Distances.

Twin manuals on *Heat* and *Light* have been prepared for the Cambridge Natural Science Series (Macmillan & Co., New York, $1 each), by *R. T. Glazebrook*, as elementary text-books, theoretical and practical, for the purpose of serving as aids in teaching by experiments that may be performed by the pupils themselves. Most of the experiments described have been in use for some time as a practical course for students in the Cavendish Laboratory. The rest of the two books contain explanations of the theory of the experiments and accounts of the deductions from them, which have formed the substance of the author's lectures to his class.

The general purpose sought by *Henry Wood* in preparing the *Political Economy of Natural Law* (Lee & Shepard, Boston, $1.25) was to outline a political economy which is natural and practical rather than artificial and theoretical. While independent of professional methods, it aims to be usefully suggestive to the popular mind. The present volume, though substantially a new work, may be regarded as a development from a small book entitled Natural Law in the Business World, published in 1887. A portion of the original matter in that book has been retained, somewhat changed in form. No attempt is made to make people content with things as they are, but to turn the search for improvement in a promising direction. We are glad to see that the author sets himself squarely in opposition to the fallacy that the interest of labor is naturally antagonistic to other social elements, which he thinks justly has done much harm.

After the Congress of Mathematics, held in Chicago, in August, 1893, a *colloquium* on Mathematics was held by Prof. *Felix Klein*, of the University of Göttingen, with such other members of the congress as chose to participate, at the Northwestern University, Evanston. During these colloquia Prof. Klein delivered daily lectures, the substance of which was taken down and prepared for publication by Alexander Ziwet. These lectures are now published as a single volume of *Lectures on Mathematics* by Macmillan & Co., New York ($1.50). Three of these lectures relate to the work of the mathematicians Clebsch and Sophus Lie; the others are on The Real Shape of Algebraic Curves and Surfaces, Theory of Functions and Geometry, The Mathematical Character of Space Intuition and the Relation of Pure Mathematics to the Natural Sciences, The Transcendency of the Numbers e and π, Ideal Numbers, The Solution of Higher Algebraic Equations, Some Recent Advances in Hyperelliptic and Abelian Functions, The Most Recent Researches in Non-Euclidean Geometry, The Study of Mathematics at Göttingen, and The Development of Mathematics at the German Universities.

Mr. *Charles H. Clark* has prepared his book on *Practical Methods in Microscopy* (D. C. Heath & Co., Boston, $1.60) in view of his observation that in most of the excellent current books on the microscope too much is assumed to be known by the pupil, or is left to be filled in by an instructor. None of them, he says, gives to the private worker in simple and concise language detailed directions for the many processes that he must learn in order to make practical use of the microscope. The present book is the outgrowth of the author's experience in the use of the instrument in the branches of scientific study pursued in the secondary schools. So much of the mechanical construction of the microscope is given as seems absolutely essential to an intelligent understanding of the instrument. The theory of polarized light has been somewhat fully considered.

The peculiar features of the *Practical Business Bookkeeping by Double Entry* (D. C. Heath & Co., Boston, $1.55), as set forth by the author, *Manson Seavy*, are classification of the subjects treated into parts, each forming by itself an independent whole, with subdivisions; full and systematic treatment, with illustrations of recounts; omission of discussion of theory; the acceptance of the forms universally adopted by the best business men and accountants in the treatment of business transactions; full discussion of bills receivable and bills payable; and the original, simple, and intelligible rules given for closing a ledger, which have stood the test of many years with classes of young students. The work is supplemented by another, The Manual of Business Transactions, which contains transactions only, in the describing of which the student must exercise his own judgment, and thus acquire proficiency in the application of principles.

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POPULAR MISCELLANY.

Meeting of the American Association.—The forty-third meeting of the American Association for the Advancement of Science will be held in Brooklyn, N. Y., August 15th to 24th. The names of the officers were given in The Popular Science Monthly for October, 1893. The rooms of the Polytechnic Institute, the Packer Institute, the Art Association, the Long Island Historical Society, and the Academy of Music have been offered for the use of the association. The meetings will be held mainly in the buildings of the Polytechnic and Packer Institutes. The headquarters of the association will be at the St. George Hotel, Clark Street. The Ladies' Reception will be given August 16th. An unusually varied and attractive list of excursions is offered, including free excursions to Long Branch; Cold Spring Harbor, Long Island, where are the Biological Laboratory of the Brooklyn Institute and the station of the New York Fish Commission; up the Hudson to West Point and return; and around the harbor; geological excursions to six points of interest; mineralogical excursions to six points; botanical excursions to five points; zoölogical excursions to four points; excursions for engineers to the Navy Yard and the Brooklyn Bridge; and an excursion to the White Mountains to attend the Congress of the American Forestry Association. The pay excursions will be at reduced fares. The meetings of the associations and societies affiliated with the General Association will be held before and during its meetings, beginning with those of the Geological Society of America and the American Microscopical Society, August 13th.

Classes in Economics.—Instruction in the Department of Economics in the School of Applied Ethics, Plymouth, Mass., during the session July 12 to August 15, 1894, will be devoted to a discussion of the relation between economics and social progress. The idea which underlies it is, that all phases of social activity and living are necessarily bound together, and consequently that no problem in which human relations are a prominent factor, whether theoretical or practical, can be properly understood, except it be studied in the light of some comprehensive theory of social development. The same general purpose will be recognized in the adjustment of courses in the other departments of the school, which include those of History of Religious and Applied Ethics. The scheme of lectures includes courses by Prof. H. C. Adams, director, on the Historical Basis of Modern Industries, Relation of Economic Theory to Social Progress, and The Transportation Problem; by Prof. J. B. Clark, on The Ethics and the Economics of Distribution; by Prof. R. Mayo-Smith, on Ethnical Basis for Social Progress in the United States; by President E. B. Andrews, on Civilization and Money; their Relation illustrated by the History of Money; by Prof. F. H. Giddings, on The Social Functions of Wealth; by Prof. J. W. Jenks, on the Relation of Political and Industrial Reform; and by Dr. E. R. L. Gould on Practical Problems in Municipal Economy.

The Benefits of Sanitation.—A paper on The Achievements of Sanitation measured by Vital Statistics, by George E. Willetts, of Lansing, Mich., contains some suggestive data bearing on the usefulness of modern sanitation. Having sought for some compilation of death-rates from a number of the principal diseases reaching back for so long a period as to tell a connected story concerning such diseases, without being able to find it, Mr. Willetts carefully worked out the subject himself from selected data relating to mortality from fevers, cholera, consumption, smallpox, and all causes as recorded

in the death-rates of England, Sweden, the city of London, etc. The result is a demonstration of the alteration for the better that has taken place in modern times in the rate of mortality from these causes. Diagrams prove graphically that a marked diminution in the death-rate has taken place, especially in the last half century, or since the efforts at prevention and restriction of infectious diseases have become systemized. Facts are brought out in Mr. Willetts's presentation showing that the theory of M. Carnot, that the saving of life from infectious diseases is only apparent, and is made up for by an increased mortality from certain other causes of death, is untenable, for the death-rate from all causes declined during the period under examination. The doctrine of Malthus, likewise, that the effect of diminution of the death-rate is to cause the population to press more closely upon the limits of subsistence, is negatived by the fact which appears that the rate of pauperism has declined in England coincidently with the fall of the death-rate. It also appears that the population is increasing least rapidly where good sanitary conditions have prevailed. The effect of sanitary improvement is thus seen to be, not in the direction of an over-production of the human race, but toward a better regulated and governed increase.

Expansion in Public Documents.—The latest report of the State Mineralogist of California furnishes an interesting object lesson as to the manner in which literature is prepared at the expense of the Government. The report relates, or is supposed to relate, to mining. The Governor of the State, in his message, objected to the voluminousness of this as well as some of the other department reports, saying that none but the unemployed and those directly interested and expecting to derive personal benefit from them could find time to read them; intimating that too little time was devoted by their authors to condensing their statements; and suggesting that while the printing of the mineralogical report would cost ten thousand dollars, "two thousand dollars worth of intelligent editorial work bestowed upon the manuscript would have saved four times that amount in the cost of printing, and the volume would have been of greater value to those interested. People," he added, "will not read long, tedious reports, and if it were not for the condensed statements given out through the press the people of the State generally would have very little information in regard to our public institutions." An appropriation having been made for the purpose, the material was put into the hands of an editor for condensation. He found several of the articles that had been prepared not directly related to the subject, though possibly of scientific value and doubtless suitable for publication through other channels, such as an academy of sciences, a geographical or an ethnographical society. In some cases the same ground was covered by the special reports of two or more assistants; in other cases matter was substantially repeated from previous reports, while no attempt had been made in either category to prune any excrescences. The manuscript showed no signs of having been edited, aside from the mere paging of the leaves and arranging in order. In parts of the manuscript that had been copied in the office, errors of copyists entirely unfamiliar with mining affairs had been retained without revision or attempt to correct them. Finally, the editor reduced the 2,307 pages of manuscript, largely type-written, to about 844 pages, or 954 pages if an article on mining law, valuable but not relating exclusively to California, is retained; and in doing this believes that he has retained all the matter proper for the report. This excessive expansiveness is not found in the public documents of California alone. We have observed it in those of the United States in more than one department.

The Soda "Lake" of Wyoming.—As described by H. Pemberton, Jr., and George P. Tucker, there exists a deposit of sulphate of soda, locally known as a "lake," about fourteen miles southwest of Laramie, Wyo. The deposit is composed of three of these lakes lying within a stone's throw of one another—the Big Lake, the Track Lake, and the Red Lake—having together a total area of about sixty-five acres. They are the property of the Union Pacific Railroad Company, are connected by a branch of that road with the main line at Laramie, and are generally known as the Union Pacific Lakes. In these lakes the sulphate of soda occurs in two

bodies or layers. The lower part, constituting the great bulk of the deposit, is a mass of crystals of a faint greenish color, mixed with a considerable amount of black, slimy mud. It is known as the "solid soda," and is said to have a depth of some twenty or thirty feet. Above this solid soda occurs the superficial layer of pure white crystallized sulphate of soda. This is formed by solution in water of the upper part of the lower body, the crystals being deposited by evaporation or by cooling, or by the two combined. A little rain in the spring and autumn furnishes this water, besides which innumerable small sluggish-flowing springs are present in all the lakes; but on account of the dry air of this region the surface is generally dry, or nearly so, and in midsummer the white clouds of effloreseent sulphate that are whirled up by the ever-blowing winds of Wyoming can be seen for miles. The layer of white sulphate is from three to twelve inches in thickness. When the crystals are removed, the part laid bare is soon replenished by a new crop.

The Tea Gardens of Johore.—Johore is an independent kingdom—the only one now in the Malay Peninsula—on the Strait of Malacca, and fourteen miles from the British colony of Singapore. It is one of the richest native states in Asia—rich in its deposits of tin and iron, and in its virgin forests of valuable tropical trees, and in the productive capacity of its soil. The present sultan, Abu Bakar, has experimented liberally in the development of the native crops of tapioca, cocoa, sago, gambier, spices, and gums, and has introduced the cultivation of tea, coffee, and pepper with such success that they now form the chief products of the kingdom. The Johore tea has been declared by experts to be of a very superior quality. The moist heat required by the tea plant is afforded in such perfection by the climate of Johore that the plants flush, or afford the fresh shoots from which the young leaves are picked to make our tea, all the year round. The bushes are planted in rows about five feet apart, with a space of about five feet between the stools. Each bush flushes about three times a month; and once a year it flowers, and is then pruned. The leaves are picked by Chinese or coolies, who turn in their pickings twice a day, and are paid by the piece. An industrious picker can pick, when the flush is good, as much as sixty pounds of green leaf a day, which will make a little more than fourteen pounds of dried leaves. The green leaves are carefully "withered" in bamboo trays by experienced Chinese operators till they are sufficiently dried—a fact which is determined by the touch; they are then rolled, either by hand rollers or rollers worked by steam, in such a way that they are pressed and twisted without losing juice. After this they are placed in heaps upon a bench, where they are turned over and over again by hand, to be "fermented," till they lose their original green and become blue; thence they are removed to a large drying chest called a sirocco, and exposed to a heat of 260° F. Each sirocco will hold four trays, which are placed at different levels. The first batch of leaf is placed on the top tray, and after a few minutes is withdrawn, turned over by hand for a while, and is then placed on the second tray, while the first tray is filled with a new lot. The operation is repeated until each lot has had four treatments, when it is considered "made." The tea is then sorted in revolving cylinders made of wire work of different degrees of fineness. As the cylinders revolve, the tea in the top one works through the meshes, according to size, into the cylinder below it, and so on. The meshes determine the grades, which are known as broken orange pekoe, orange pekoe, broken pekoe, pekoe, pekoe souchong, and souchong, in the order of their value. More than half—perhaps sixty per cent—of the making will be souchong. Next come the weighing and packing. Four and a quarter pounds of green leaf are supposed to make a pound of "made" tea.

Early Alpine Climbing.—In prehistoric times, says Mr. W. M. Carney, the Alps were traversed by two or three trade roads, the most important being that along which the exchange in bronze and amber took place. Italy was invaded over more than one pass in early times. In the mediæval period the passes of the Alps were largely used by pilgrims, the Great St. Bernard being their favorite route. An interesting account is extant of the passage of this route in winter by Abbot Rudolf, of the Troad, in the year

1128. An itinerary of the way was drawn up about 1154 by Abbot Nicholas, of Thurgör, in Iceland. It was a kind of guidebook for pilgrims. The climbing of mountains has occurred sporadically from ancient times. Hadrian climbed Etna to see the sunrise. In the eleventh century an attempt was made to climb the Roche Melon, but the summit was not reached till 1358. Toward the end of the thirteenth century Peter III of Aragon climbed Canigon in the Pyrenees, and saw a dragon on the top. In 1339 Petrarch climbed Mont Ventoux, near Vaucluse, "to see what the top of a hill was like." Charles VIII of France sent one of his chamberlains up the wall-sided Mont Aiguille in 1492. Leonardo da Vinci's general scientific curiosity led him to pay attention to mountains, and he appears to have ascended some part of Monte Rosa to a point above the snow line. In the sixteenth century the study of mountains advanced considerably, and a group of regular mountaineers was almost formed at Zurich, but civil and religious troubles blighted their enterprise. Conrad Gesner and Josias Simler were their leaders. The former appears to have been infected with the regular mountaineering ardor of the modern sort. Simler published a valuable and interesting book about the Alps, in which he gave sound, practical advice to climbers. During the first half of the seventeenth century mountains were neglected. Dragons were still supposed to linger among them, and they were thought to be the homes of devils, against whom outpost chapels were built.

Peat-moss Atolls.—The attention of Mr. Conway Macmillan has been directed to examples of a peculiar and hitherto unrecorded peat-moss formation observed in some of the lakes of Minnesota. From their position in the middle of ponds of considerable size, he has named them sphagnum atolls. Ballard's atoll is situated in an almost circular pond about a hundred and fifty yards across, which is surrounded, except for a short distance on the west, where a channel has been cut between two low jutting bars. The atoll appears from the surrounding hills as a ring of green, conspicuous and sharply defined, about seventy-five feet in diameter, and having a uniform width of about ten feet. Another atoll, Anderson's atoll, is in a pond about fifty yards across, with high banks, and forms a ring within a foot or two of twenty yards in diameter and having a breadth of about twelve inches. Both atolls support a diversified vegetation, which is not alike on the two. This vegetation likewise differs from that of the pond outside and of the inner lagoon, and varies with the development and desiccation of the atoll. The origin of these formations is ascribed by the author to a season of gradual recession of the waters of the pond, when a loose turf was formed, lining the edges of the pond, followed by a season of comparatively rapid increase in area and level, when this surface became detached from the shore. The atolls then probably first appeared as annular floating bogs, separated from the shoreward turf as a result of the original zonal distribution of littoral plants and the rise of the waters, together with the favorable concurrence of a group of special and necessary conditions. Some of the apparent conditions of atoll formation are a definite maximum size and depth of the present pond; considerable height and regularity of the banks of the present pond (whereby the zone of vegetation is protected from violent winds); a regular and gentle slope of the pond bottom from shore to center; a definite original character of littoral vegetation when the pond was at a low level; a reduction within minimum limits of the lateral pressure and tension of winter ice; and a comparatively prompt anchoring of the atoll upon the bottom.

Dakota Climates.—The Dakotas are divided, according to Dr. D. W. Robinson, into two climatic regions by the range of hills and highlands known as the Missouri Divide. In the east divide country "many of the essential characteristics of an ideal health region are present. . . . Excessive cloud and dampness are not present beyond what is needed for successful agriculture. The air is rare, pure, and exhilarating. Diseases of an acute character are not extensively prevalent, and outbreaks of epidemic disease are rare and easy to control." The upper Missouri basin, which is about three hundred miles long, between a hundred and three hundred miles wide, and rises from twelve

hundred to sixteen hundred feet at the Missouri Valley to from eighteen hundred to three thousand feet at the brines, "is the sunland of Dakota. It is drier than the east divide country." Contrary to what might be expected in a latitude so far north, the winters are short. The season usually begins about the holidays; with the exception of a few disagreeable days that come with the late fall rains, the weather is usually delightful. At times in midwinter the thermometer registers much below zero. These days of low temperature invariably follow a fall of snow, and before the bright sunshine that is sure to come has tempered the dry, cutting atmosphere. A very notable feature of this climate to those who have never before spent the winter in Dakota is their ability to pursue their outdoor employments on the coldest days without unusual discomfort. A temperature that would render outdoor pursuits impossible in an air laden with moisture will in this dry, sunny air be almost unnoticeable. Storms are frequent, but not as a rule destructive or dangerous. Probably the most disagreeable feature of this season as well as of all seasons in the Missouri basin are the sudden and ofttimes extreme changes of temperature. But in the coldest weather the United States Signal reports show that the temperature is not so low by several degrees at Pierre or Bismarck on the Missouri River as in the same latitudes east of the Missouri divide. Spring begins early. The warmth and sunshine bring this season fully a month in advance of the damper localities in the same latitude and many miles south in the Mississippi. In summer the days are often warm, but rarely oppressive. The autumn is the most delightful season of the year, and the year usually passes away with it. The favorable features of Dakota for health-seekers are that it possesses the proper altitude; that it has a water supply of the very purest; that by far the largest number of days of all seasons are days of sunshine; that it has a dry, porous soil; that it can not for years be overcrowded; that severe and fatal diseases do not extensively prevail; and that it has plenty of advantages for industrial pursuits, thousands of acres of cheap productive land, and a place where the poor and the prospective invalid can found a permanent home. The disadvantages are, that there are present to a certain degree sudden and depressing atmospheric changes; and that it lacks a great variety of means for diversion, although hunting, fishing, horseback riding, and other sports can be followed almost daily.

Mind Cures.—Why, asks Dr. A. T. Schofield, of Friedenheim Hospital, are not the great therapeutic powers of the mind given their due place and prominence in medical treatment? "Does any practical medical man doubt these powers? Is he not aware of the ingredient 'faith' which, if added to his prescriptions, makes them often all-powerful for good? Does he not know the value of strongly asserting that the medicines will produce such and such effects as a powerful means of securing them? Has he never witnessed the therapeutic value through the mind of the dentist's waiting room in curing toothache, or of the consultant's spacious dining room and back numbers of Punch, combined with the physician's august presence in the consulting room? And has he not seen how much more efficacious the very same drugs have proved when prescribed in such solemn surroundings than in his own humbler environment and less august presence?" Among the most valuable instruments of mental therapeutics is the mantelpiece striking clock. Sir Dyce Duckworth insists upon the great efficacy, in cases of persistent vomiting, of giving the liquid food in teaspoonfuls every five minutes *by the clock*. Food thus given is more readily retained, and all the more so if the clock can be clearly observed by the patient himself from the bed. At the exact time the mind, acting through the brain, enables the stomach (perhaps by some inhibitory power over the vomiting center in the medulla) to retain the food. The clock has also proved to be valuable in labor in promoting regularity in the intervals between the pains, as well as in the appointment of the hours for nursing the child. Its real value in these, as in all cases, is truly scientific, and lies in its potent aid toward rapidly forming accurate psycho-physical habits or artificial reflexes in the brain. The clock is a strong aid to sleep by enabling a person to go to bed at exactly

the same hour every night; regularity in this matter is a powerful hypnotic.

Effects of Wind on Soil.—Investigations by M. J. A. Hensele show that when the wind bears in an acute angle upon the surface of a soil it produces a pressure of the air of the soil that increases with the speed of the wind and the increase of the angle of incidence. The excess of pressure diminishes as the strata grow deeper. The pressure determined by the wind increases with the grossness of the particles and as the structure is grumelous. The wind provokes a diminution of richness in carbonic acid of the air of the soil, which becomes greater with increase of velocity. It also increases the evaporation of water from the soil. Wind striking the ground at an angle occasions an evaporation of more unequal force than when it blows horizontally. Richness in moisture has much influence in retarding evaporation, while elevation of temperature quickens it. The wind has no direct influence on the capillary ascent of water in the soil, but only acts indirectly by favoring evaporation and thus provoking a movement of water toward the surface as long as there is much of it in the soil. The temperature of the soil is depressed by wind in proportion to its velocity and the magnitude of the angle of incidence.

Behavior of Different Trees to Lightning.—The resistance of different trees to the electric spark has been studied by M. Jonesco Dimitrie, who placed pieces of sapwood of beech and oak in the way of the spark of a Holtz electrical machine. The spark passed through the oak after one or two revolutions of the machine, while twelve or twenty revolutions were required to give it force enough to pass through the beech. Five revolutions were sufficient with black poplar and willow. Ssmilar results were obtained with heartwood. The presence of water had no influence on the resistance, but richness in fat was an important factor. "Starchy trees," poor in fat, like the oak, poplar, willow, maple, elm, and ash, opposed much less resistance to the spark than "fatty" trees, like the beech, chestnut, linden, and birch. The pine, which is rich in oil in winter and poor in it in summer, shows a corresponding difference in behavior toward the spark at those two seasons. In the "starchy" trees the living wood was harder to strike with the spark than the dead wood. The bark and foliage are poor conductors in all the trees, but this is of little importance as compared with the conducting power of the tree itself. These results are in harmony with what has been observed as to the relative frequency with which trees of these several species are struck by lightning. The author found also that station and soil affect the liability of trees to be struck. The vicinity of water augments the danger. Isolated trees seem more liable than those which are massed. All species of trees may be struck when the electric tension is high.

Speech Tones.—Attention is called by Alexander Melville Bell to the tones associated with speech as a subject deserving scientific investigation. These tones are generally spoken of as accents. "Thus we say of a stranger that he has a foreign accent; or we may define the peculiarity and say he has an Irish, a Scotch, a French, a German, a Western, or a Southern accent. He may or may not add to this some distinctive pronunciations affecting vowels or consonants; but independently of these he will use in his phrases and sentences a combination of tones—a tune—which alone would suffice to suggest the nationality of the speaker. All national speech has its characteristic tune. This is especially noticeable in dialects of the same language. We are but little cognizant of our own habitual tunes, but we are at once sensible of any marked deviation from them in the speech of others." The author devotes a very interesting paper, which he read before the Modern Language Association last December, to the analysis of these "speech tones." He especially discusses the tones of the Chinese language.

Bacteria in Butter-making.—In a bulletin of the Storrs Agricultural Experiment Station, Connecticut, on the Ripening of Cream by Artificial Bacteria Cultures, the chief object of the ripening of cream is shown to be to produce the butter aroma. This aroma, though very evanescent, con-

trols the price of the butter. The butter-maker owes the aroma to the bacteria, for by their growth the materials in the cream are decomposed, and the compounds are formed which produce the flavors and odors of high-quality butter. Different species of bacteria vary much as to the flavors which they produce, some giving rise to good, some to extra fine, and others to a very poor quality of butter. A majority of our common dairy species produce good but not the highest quality of butter. Heretofore the butter-maker has had no means of securing the best flavoring bacteria; but now the bacteriologist can isolate and obtain in pure cultures those species which produce the best-flavored butter, and can furnish them to the creameries to use as starters in cream ripening. This artificial ripening of cream promises much for the near future, but it has so far been applied on only a small scale.

NOTES.

The third summer session of the School of Applied Ethics is to be held at Plymouth, Mass., July 12th to August 15th. A special feature will be the attention given to the labor question and allied subjects in each of the departments. In the Department of Economics the relation of economics to social progress will be discussed by leading economists from different universities. In the Department of Ethics and History of Religion various phases of the labor problem in the past and present will be considered by a large corps of able educators. The relation of various forms of educational activity to ethical and social progress will be considered at a conference of educators and teachers, August 5th to 11th, and opportunity will be afforded for free and full discussion.

A committee has been formed in Paris, with M. Pasteur at its head, to raise funds for the erection of a monument to the memory of M. Charcot.

In a lecture at the Royal Institution on the Electric Discharge through Gases, Prof. J. J. Thomson deduced from experiments the conclusion that the conductivity of gases at a certain degree of rarefaction is greater than that of any metal, and almost infinitely greater molecule for molecule. At a higher degree of rarefaction, however, conductivity is diminished, and in a perfect vacuum, as has been shown by some of Prof. Dewar's experiments, it is probable that the discharge would not pass at all. From another series of experiments it was inferred that electric currents will cross a high vacuum freely though they produce no glow to indicate the fact.

Why man can not swim without having learned, while other animals can, is explained by Mr. Robinson in the Nineteenth Century. It is a question of atavism. When in great danger we make the defensive movements most familiar or instinctive to us. The first impulse of quadrupeds is to run away, and the movements of running sustain them in the water, while man, true to his simian ancestors, tries to catch hold of something, and pushes his arms up, with the sure result of himself going down.

A curious colloidal form of gold, soluble in water containing basic acetate of cerium, is described by Herr Schottlander. The solution is of a very intense reddish-violet color, turning to carmine red in dilute solutions. The color still remains distinct in a solution containing only $\frac{1}{500000}$ of gold. These solutions are obtained by precipitating a dilute solution of a salt of cerium mixed with gold, by means of a lye of potash or soda. The green precipitate obtained is then dissolved in warm dilute acetic acid. The acetate of soda then gives a violet-red precipitate containing all the gold in the liquor and a little basic acetate of cerium. On drying this precipitate an amorphous bronze-colored mass, soluble in water, is finally obtained.

The French Museum of Natural History received, a few months ago, a specimen of that rarest of birds, the *Apteryx*. It was carefully kept in a warmed room and fed with expressly chosen and prepared meats, for it was not supposed it could thrive in a foreign climate and among strange associations. One day in October it was gone, and could not be found, though the whole *Jardin des Plantes* was searched for it, till early in March a dog smelled it out in one of the ventilating holes of a row of newly erected buildings, in the cellar of which it had endured cold and rain and snow through the winter, and lived on what it could pick up. Never had it been known to be in better condition.

Orchid culture, as we know it, according to an article quoted in Garden and Forrest from the Orchid Review, did not exist till early in the last century, when, in 1731, a dried specimen of the species *Bletia verecunda* was sent to Peter Collinson from the Bahamas. Collinson sent the tubers to the garden of a Mr. Wager, where they were nursed during the winter, and produced flowers in the next summer. Two of our North American cypripediums were cultivated, perhaps, as early as 1737. At the end of the century there were cultivated in English gardens, besides several hardy species, orchids which had been brought home by travelers and naval and military officers from

the West Indies, China, and the Cape of Good Hope. Our beautiful little *Calopogon pulchellus* was introduced accidentally in some bog earth which had been taken over to England with some plants of *Dionea* for the botanist Curtis. His gardener noticed some small, toothlike, knobby roots in the soil and took care of them so that they flowered in the following summer. The first orchid was figured in 1790 from the strongest of these plants.

Philibert Commerson, the eminent naturalist and botanist of Bougainville's scientific and exploring expedition, 1766–'69, wrote of Réaumur, the entomologist and author of the Réaumur thermometer scale: "Réaumur, the illustrious Réaumur, has just died from the effects of a fall which caused a suppuration of all the internal parts of his head. Thus the poor insects have become orphans for a long time, for we other Linnæists are nothing but cruel impalers; but Réaumur was their father, their *accoucheur*, their nurse, their interpreter, their all."

The results of examinations of European statistics by M. Lagneau go to show that as among occupations consumption is most prevalent among persons whose callings expose them to dusts; and next among those whose work is sedentary; while persons living in the open air enjoy an almost complete immunity. From another point of view, consumption appears to increase in towns rapidly with the density of the population.

Remarking upon a proposal to establish a psychological laboratory in England, similar to the institutions of the kind that exist "all over the Continent," the *Revue Scientifique* observes that there is only one such laboratory in France deserving the name, and that to find really important installations it is necessary to go to Germany or to the United States; and that the English in arranging their experimental establishment will have to draw their inspiration from these two countries.

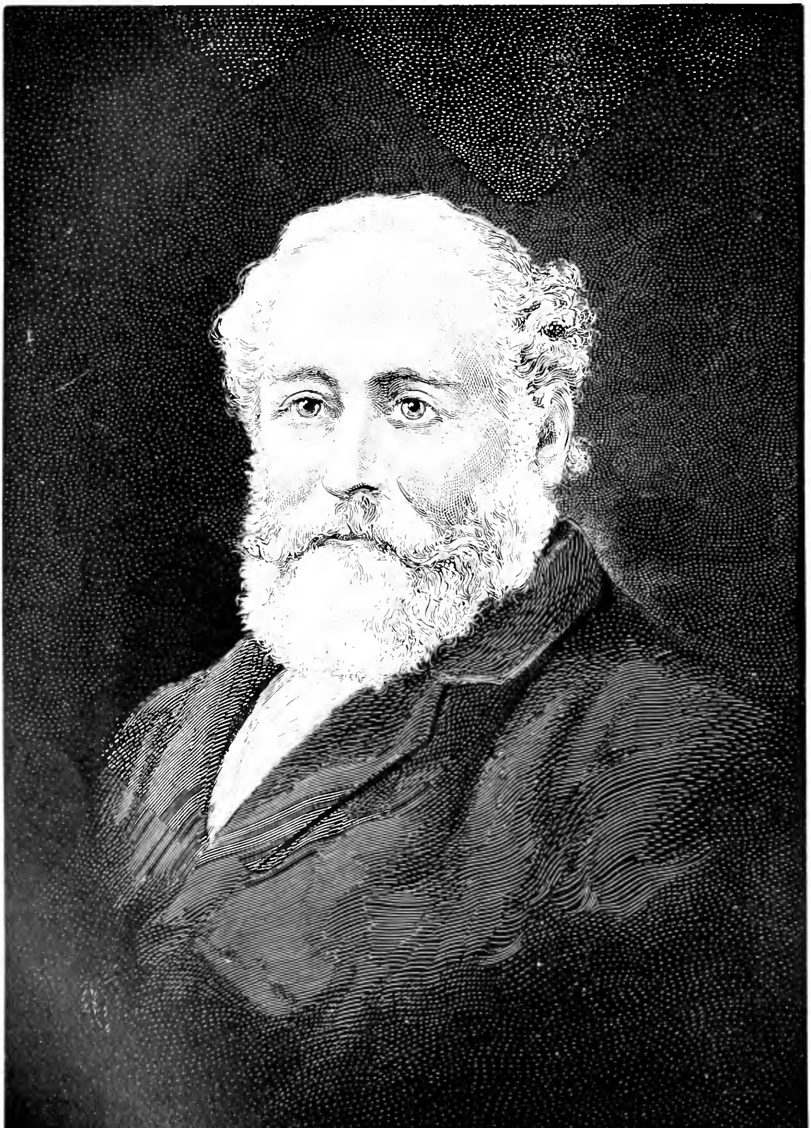
The Geographical Club of Philadelphia was formed in 1891, and its first stated meeting was held February 24, 1892, when the president, Prof. Angelo Heilprin, read an opening address on the Present Aspects of Geographical Study. Since then, till January, 1894, twelve stated meetings have been held at which important and interesting papers have been read. The club was incorporated in May, 1892. Its purpose is defined to be the advancement of the science of geography and of geographical studies and exploration, the recording of discoveries, the presentation of researches, and the accumulation of works on geography. Among the features of its history to this time are its association, through a contribution of funds, with the Peary Arctic Expedition of 1893, and the issue of the first number of its Bulletin, containing an address, by Mr. E. S. Balch, on Mountain Exploration.

The English Society for the Protection of Birds aims at preventing the destruction of beautiful and useful birds by influencing public opinion, and, if possible, by promoting legislation. Mr. E. H. Bayley, M. P., the president, referred, in his address at the annual meeting of the society, to the wholesale catching and killing of birds for purposes of sale, or for so-called sport. As an example of abuse in sport, he instanced a case which had been brought under his notice of a man who went down to Devonshire from London, and in a short time destroyed all the kingfishers on a certain stream. The number of members of the society has increased in one year from 5,200 to 9,159.

OBITUARY NOTES.

Prof. George John Romanes, author of the work on Animal Intelligence in the International Scientific Series, of the books, Mental Evolution in Animals and in Man, and Jellyfish, Starfish, and Sea Urchins, and of other scientific essays and treatises, died suddenly at Oxford, England, May 23d. He was born in Kingston, Canada, in 1848, spent his boyhood in Europe, and was graduated in Natural Science at Cambridge in 1870. His first scientific writings of mark are a series of papers on the Nervous System of Medusæ. He was elected a Fellow of the Royal Society in 1879. He held the appointment of Fullerian Professor of Natural History in the Royal Institution, London, and Rosebery Lecturer on Natural History in the University of Edinburgh. He was a personal friend of Charles Darwin; and most of his writings were in development of Mr. Darwin's theories and the doctrine of evolution, or in criticism of them.

Prof. Robert Peter died at his home near Lexington, Ky., on the 27th of April, at the age of eighty-nine. He is well known among the older generation of scientific men for his chemical work in soil analyses in connection with the various geological surveys of Kentucky and Arkansas. He was a contemporary of many of the older men of science, and was for many years personally and officially associated with David Dale Owen in his geological work. He was the oldest medical professor in America, and occupied the chair of Chemistry in the Transylvania University in its earliest days. When that school was removed to Louisville and became the Kentucky School of Medicine, he went with it. At the time of his death he occupied, nominally, the chair of Chemistry in the Agricultural and Mechanical College at Lexington. He was a native of Cornwall, England, and was born in 1805.



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THE CHAOS IN MORAL TRAINING.

By JOHN DEWEY,

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IN teaching undergraduates in the subject of ethics, I have been impressed with the need of getting the discussion as near as possible to what is going on in the minds of students themselves. Although ethics is the most practical of the philosophic studies, none lends itself more readily to merely technical statement and formal discussion. It is easy to forget that we are discussing the actual behavior, motives, and conduct of men, and substitute for that a discussion of Kant's or Mill's or Spencer's theory of ethics. It seems to me especially advisable to get in some contact with the practical, and accordingly largely unconscious, theory of moral ends and motives which actually controls thinking upon moral subjects. One is, however, considerably embarrassed in attempting this. As any one knows who has much to do with the young, their conscious thoughts in these matters, or at least their statements, are not fresher, but more conventional, than those of their elders. They are apt to desire to say the edifying thing, and the thing which they feel is expected of them, rather than express their own inner feelings. Moreover, some points have been so much discussed that any direct questioning upon them is apt to bring forth remnants of controversies that have been heard or read, secondhand opinions, an argumentative taking of sides, rather than to evoke the spontaneous and native attitude. Among other devices for eliminating or at least reducing these disturbing factors the following method was hit upon: To ask each student to state some typical early moral experience of his own, relating, say, to obedience, honesty, and truthfulness, and the impression

left by the outcome upon his own mind, especially the impression as to the reason for the virtue in question. The answers brought out a considerable mass of material, incidentally as well as directly. Some of this seems to me to have value beyond the immediate pedagogical occasion which called it forth, as furnishing a fairly representative sample * of the motives instilled by existing methods of moral training, and the impressions which these methods leave behind.

Nine tenths of the answers may be classified under one of the following heads: The impression left by the mode of treatment was that the motive for right doing is (1) found in the consequences of the act; (2) fear of being punished; (3) simply because it is right; (4) because right doing pleases the parent, while wrongdoing displeases; (5) the religious motive. In number the religious motive predominates; next to that comes fear of punishment. In many cases, of course, several of these reasons were inculcated.

1. The regard for consequences as a reason for morality takes the form of regard either for external consequences or for intrinsic reactions—that is to say, upon the character of the agent or upon those about him. A number seem to have learned the value of obedience by observation of disagreeable results proceeding from its opposite. For example, one child was told not to take off her shoes and stockings; she disobeyed, and had croup in the night—whence, she remarks, she derived the idea that others knew more than she, and that disobedience was dangerous. Another girl was told not to wear a lawn dress to a picnic; she disobeyed, but a rain storm came up and faded it out. "From this and other similar experiences I deduced the idea that obedience was wise. Yet this was with the reservation that obedience was to be tempered with discretion, as I observed that in some instances acting upon my own judgment was justified by the outcome."

When we come to the moral motive as determined by the intrinsic results of the act, we are obviously approaching the question, so mooted upon its theoretical side, of intuitionalism *versus* empiricism. Nothing was said upon this point in giving out the questions; the students may fairly be presumed to have been unconscious of any such bearing in their answers, and so these may be taken as fairly free from any bias. No one reply indicates any distinct recognition of right or wrong prior to the commission of

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* The class numbered over one hundred. About ninety replied. About twenty of the answers were put aside, as indulging in general statements, or as bearing the stamp of artificiality. The remaining answers represent Central Western States, particularly the States of Michigan, Illinois, and Indiana. Pretty much all grades of homes are represented, and at least three lines of descent beside native American.

some particular act.* After acting, a number of persons note the fact that they became so uncomfortable that they either owned up or resolved not to do that sort of thing again. This experience, however, is noted only in the case of a lie told or acted. Several expressly state that obedience and honesty (as a regard for the property of others) appeared quite artificial, their need being seen only after considerable instruction and some rather crucial experiences. Obedience, in many cases, seemed quite arbitrary—"necessary for children," as one puts it, "but not for grown people"; or, as another notes, "till he got big enough so he wouldn't have to mind"; while a third states that obedience, as such, was always accompanied with a certain resentment and a desire to have the positions reversed, so that he could do the commanding. As for honesty, one says that it always seemed to him that anything he wanted to use belonged to him; another, that any pretty thing which she admired was her own. One child notes that she saved up the pennies her father had given her to take to Sunday school, and bought a valentine with them, which she gave to him, to surprise him. The father threw this into the fire first, and then punished her, taking it for granted that she knew she was doing wrong.† Not even after that, however, did she feel it was wrong, but rather felt indignant and humiliated that her father had treated her gift in such a way. Another child could see no wrong in taking the pennies from a bank which she and her sister had in common. The following instance is worth quoting in full: "Before I was four, I remember several instances in which I saw moral delinquencies in others, which I wished to punish or did punish, but none in myself. As to honesty, I claimed all the eggs laid in the neighborhood as coming from my own pullet. After being convinced of the physical impossibility of this, it was a long time before I would believe that everything I laid hands on was not mine. I was once driven off from a field where I was picking berries; this made a great impression upon me, and led to questions regarding the rights of others to be so exclusive. The effectual appeal always lay in being led to put myself in the place of others." A number note that there was great difficulty in appreciating that a fence could institute a moral barrier between mine and thine. But as regards lying, a few report having been

* This *may* be due, of course, to the way in which the question was put.

† A sense of injustice seems to have been the first distinctly moral feeling aroused in many. This, not on account of the wrong which the child did others, but of wrong suffered in being punished for something which seemed perfectly innocent to the child. One of the distinct painful impressions left on my own mind by the papers is the comparative frequency with which parents assume that an act is consciously wrong and punish it as such, when in the child's mind the act is simply psychological—based, I mean, upon ideas and emotions which, under the circumstances, are natural.

made thoroughly uncomfortable by its after effects in their own emotions. The following story, trivial in itself, is not trivial in meaning: "Once, when I had two apples, I wished to give one to my playmate; I knew she would expect the best one, which I also wished for myself, so I held out the best side of the poorer one and made her think that was the better of the two. Her belief that I had really given her the best took away all the sweetness from my own apple, and I decided that straightforwardness was better." This instance, as well as others pointing in the same direction, so far as they would justify any conclusion, fall in line with the case reported by Professor James relative to the experience of a deaf-mute. This boy had stolen ten dollars, thinking it a smaller sum, having previously stolen many small amounts with no compunctions of conscience. In this case, the reaction into himself was, so to speak, so massive and bulky that he became thoroughly uncomfortable and ashamed; was brought spontaneously to recognizing its badness, and kept from stealing money in the future. This genuine meaning of the innate theory of conscience seems accordingly, to Professor James, to mean that any act, if it can be experienced with adequate detail and fullness, "with all that it comports," will manifest its intrinsic quality.*

2. An astonishingly large number record that they got their first distinct moral impressions through punishment, and of these a considerable fraction got the idea that the chief reason for doing right was to avoid punishment in the future. This division runs into that dealing with the religious motive, as sometimes the fear was of punishment from parent, sometimes from God; it also runs into the fourth head to be considered, practically if not logically, for a number record that the motive appealed to by their father was fear of punishment, while that of their mother was love of her, and grief caused by wrongdoing.

A few samples tell, in different language, the almost uniform tale of the outcome of the appeal to force. "I rebelled with feelings of hatred and of desire for revenge. It seemed to me unjust, imposed by sheer force, not reason." One tells the story of being coaxed by older boys to steal some tobacco from his father. "I was caught and given a whipping, no questions being asked and no explanation given. The result was certainly a fear of punishment in the future, but no moral impression. I thought my father whipped me because he wanted the tobacco himself, and so objected to my having any of it." Another reports that the impression left by punishment was a mixture of a feeling of personal indignity suffered—a feeling so strong as to blot out the original

* Philosophic Review, vol. i, p. 674. I can but think, however, that Professor James is very charitable in ascribing to the ordinary intuitionalist any such reasonable view.

offense—and a belief that she was punished for being detected. Another thought she was punished because her father was the stronger of the two; another, that fear of harm to self induced people to do right things; another tells that he longed for the age of independence to arrive so that he might retaliate. One upon whom fear of punishment from God was freely impressed formed the idea that if he could put off death long enough, lying was the best way out of some things. One child (five years old) went in the front part of the house after she had been forbidden, and, falling, hurt herself. She was told that this was a punishment from God; whence she drew the not illogical conclusion that God was a tyrant, but that it was possible to outwit him by being more careful next time, and not falling down. One peculiarity of the method of inducing morality by creating fear is that some parents, in order to prevent lying, deem it advisable to lie themselves; e. g., talk about cutting off the end of the boy's tongue or making him leave home, etc. But there is hardly any need of multiplying incidents; all the reports re-enforce the lesson which moralists of pretty much all schools have agreed in teaching—that the appeal to fear as such is morally harmful. Of course, there are a number of cases where good results are said to have come from punishment, but in such cases the punishment was incidental, not the one important thing; it was the emphasis added to an explanation.

3. Some report that they were instructed to do right "because it is right," either as the sole reason or in connection with other motives, such as harm to one's character, or displeasing God or parents. A little more than one tenth of the persons report this as a leading motive instilled. Most simply mention the fact, with no comment as to the impression made upon them. One remembers displeasing her mother (after she had been told that she must do right because it was right) by asking why she must do what was right rather than what was wrong. On the whole, she was confused, and the basis of morality seemed to be arbitrary authority.

4. Such answers as the following are exceedingly common: "I saw by mother's face that I had grieved her"; "was made to feel that I had shocked and pained my parents"; "the motive appealed to was giving pain to my parents, who loved me"; "I felt ashamed when I found I had grieved my father"; "was made to feel sorry when my parents were made unhappy by what I did," etc. There is a paucity of information about the attitude toward morality left by this mode of treatment. The following, indeed, is the only comment made in any of the reports: "Upon disobeying my mother, I was told that I was naughty and bad, and that she would not love me unless I was sorry and promised not to dis-

obey again. This impressed me with the *necessity* of obeying, but I did not see then, and can not now, any *reason* for it."

5. We come now to the religious motive as the ground for right doing. There are different kinds of answers here—appeals to fear and love, to Bible teachings and Bible warnings, to terror of an avenging God, and to the wounded affection of a personal friend and Saviour; sometimes one, and sometimes a mixture of all. Certain of the practical ones among the parents used, indeed, not only all these appeals, but pretty much all the foregoing mentioned as well, evidently on the principle that it is not possible to use too many inducements toward morality, and that if one fails, another may hold. I shall give one or two typical quotations illustrating each method. First, of fear: "My mother told me, 'You must tell the truth, for God knows all about it, for he is continually watching you, and I certainly shall find out all about it.' This caused great fear; we thought of God as a powerful avenger, and also believed that he communicated with our parents about our faults." Three or four mention that the story of Ananias and Sapphira was used with considerable effect. Second, of Biblical authority: "I was taught that the Bible said that these things were right and wrong, and that it must be so. I can not remember a time when I did not think that it was wrong to break any of the ten commandments, because they had been given by God in the Bible." "When I asked the reason why I should not do certain things, I was told that it was because they were forbidden in the Bible." Third, of love: "I was taught that Jesus looked upon me, just as my parents did; that he was pleased when I did right, and grieved when I did wrong, and that he had done so much for me that I ought to be sorry to grieve him." "I was taught that wrong acts grieved our Lord, and that he knew about them even if no one else did; also that he was pleased when I did any little act of kindness to any one." Fourth, mixed cases: "I was brought up in a distinctly Christian home. I was made to feel that certain things were right and their opposites wrong; was taught that there is a God who sees and knows everything that I do; that he looked upon disobedience with an eye of displeasure; the Bible was taught from early infancy as a text-book of morals; was made to feel that not only would punishment result from wrongdoing, but that both God and my parents were hurt by my wrongdoing. The impression left on my mind was that certain things were right and that God was the standard; at first fear, awe, and reverence were induced, with occasional feelings of rebellion; the general effect was to awaken respect for the right qualities, and to make me consider the right and wrong of things in my own consciousness." "After the first lie which I remember, I was not

punished, but was given a lecture on the words in the Revelation, 'Without are . . . whosoever loveth and maketh a lie.' I was made to see that the habit would grow and dishonor me in the sight of God and man, and left with the promise of a good whipping if I ever told another. In general, I remember that I was taught that my faults had the peculiarity of increasing at an astonishing rate; that I was a very naughty child, and that every wrong act grieved a heavenly Father who loved me and who was ever present to see both the good and the bad." "After lying I was told that I got no good from it; that teachers and friends disliked such persons; that my honest playmates would look down on me; that God was grieved with me. The room was filled with the splendor of the setting sun, and it seemed to me that God must be up there looking at me and seeing what a naughty girl I was. Then I was told that God would forgive me if only I confessed, and that in the future he would help me to be good if only I tried."

I am not afraid that any one will despise these incidents as trivial. It is easy, indeed, to recall our own childhood, to look out at what is now around us, and say that there is nothing new here; that all this is commonplace and just what any one would expect. Precisely; and in that consists its value. It all simply brings out the most familiar kind of facts, but still facts to which we shut our eyes, or else ordinarily dismiss as of no particular importance, while in reality they present considerations which are of deeper import than any other one thing which can engage attention. Every one will admit without dispute that the question of the moral attitude and tendencies induced in youth by the motives for conduct habitually brought to bear is the ultimate question in all education whatever—will admit it with a readiness and cheerfulness which imply that any one who even raises the question has a taste for moral truisms. Yet, as matter of fact, moral education is the most haphazard of all things; it is assumed that the knowledge of the right reasons to be instilled and knowledge of the methods to be used in instilling these reasons "come by nature," as reading and writing came to Dogberry. There is, if I mistake not, a disposition to resent as intrusion any discussion of the subject which goes beyond general platitudes into the wisdom of the motives and methods actually used. Yet I do not see how any successful training of children as to their conduct is possible unless the parents are first educated themselves as to what right conduct is, and what methods are fit for bringing it about. I do not see how that is to be accomplished without a free treatment of present aims and methods.

The first thing which strikes one's attention in these answers is the great gap existing at present between theory and practice.

Either prevailing theory is egregiously wrong, or else much of present practice, measured by that theory, may be fairly termed barbarous in its complete disregard of scientific principle. If there is one thing in theory upon which all schools are agreed, it is that conduct is not moral except as its motive is pure—except, that is, as free from reference to personal fear of punishment and hope of reward. The intuitionalist insists that duty must be done for duty's sake; the empiricist, that while consequences make the moral criterion, yet the agent is truly moralized only in so far as his motive is regard for the consequences which follow intrinsically from the act itself. And yet the main motive actually appealed to is the desire to avoid either actual punishment, whether from God or from one's parent, or else the reflex into one's self of their displeasure in the way of being grieved or hurt. The last motive appealed to, it would seem, is that connected with the act itself. Enlightenment as to the true nature of the act performed, irrespective of the source of its imposition, irrespective of the favor or disfavor which the act will arouse from others (save, of course, in so far as that disfavor or favor is, through the social structure, one of the *intrinsic constituents* of the act) and the development of interest in that act for its own sake, seem to be the last things aimed at.* It is commonly said, I know, that a child can not understand the moral bearing of his acts, and that therefore rather arbitrary and external motives must be appealed to. Of this, I would say two things: First, it is true that the child can not see in the act all that an adult sees in it. There is not the slightest reason why he should. If he did, it would be an entirely different act, an act having different conditions, a different aim, and a different value. The question is whether the child can be made to see the reason why *he* should perform the act, not why some other older person should perform it. Limiting the question in this way, it loses, I think, a large part of its force. As for what remains, it may still be said that the ideal is to appeal to the child's own intelligence and interest *as much as possible*. One of the strongest impressions made upon me by the papers is the natural strong interest of children in moral questions—not, indeed, as consciously moral, but as questions of what to do and

* I hope I shall not be understood here as arguing for the principle of doing right because it is right. In the first place, the phrase is very ambiguous, meaning either doing the act for the sake of something right, in the abstract or at large, a right whose connection with the particular act is not seen; or else doing the act for its own sake, for the meaning which the act itself has for the agent—a principle which is the extreme opposite of the other sense. But, in the second place, I am desirous to state the matter in terms upon which all schools are agreed; and I understand that (however differently they may phrase it) all schools are agreed that an act has really moral worth only when the agent does it because of what *he* sees and feels in it.

what not to do. We do not have to take any position regarding the intuitive character of moral distinctions or the *a priori* character of moral laws to be sure that a child is intensely interested in everything that concerns himself, and that what he does and how other people react to it is a very intimate part of himself. To decline to show the child the meaning of his acts, to hold that his desire to know their reasons (that is, their meaning) is a sign of depravity, is to insult his intelligence and deaden his spontaneous interest in the whys and wherefores of life—an interest which is the parent's strongest *natural* ally in moral training.

Secondly, in and so far as the child can not see the meaning and value of his acts and value them for himself, it becomes absurd to insist upon questions of morality in connection with them. Make the widest possible allowance for the necessity that a child perform acts, the bearing of which he can not realize for himself, and the contradiction in the present method is only emphasized as long as parents impress upon the children strictly moral considerations in connection with such acts. Surely, if morality means (as all moralists are agreed) not simply doing certain acts, but doing them with certain motives and disposition, rational training would emphasize the moral features of acts only when it is possible for the child to appreciate something of their meaning, and in other cases simply manage somehow to get the acts done without saying anything about questions of right and wrong. To continue the present method of holding, on one side, that a child is so irrational that he can not see for himself the significance of his conduct, while, on the other, with regard to these self-same acts, the child is punished as a *moral* delinquent, and has urged upon him, on *moral* grounds, the necessity for doing them, is the height of theoretical absurdity and of practical confusion. Present methods seem to take both the intuitive and utilitarian positions in their extreme forms, and then attempt the combination of both. It is virtually assumed that prior to instruction the child knows well enough what he should and should not do; that his acts have a conscious moral quality from the first; it is also assumed, to a large extent, that only by appeal to external punishments and rewards can the child be got to see any reason for doing the right and avoiding the wrong. Now these two propositions are so related that they can not possibly both be true, while both may be false—and *are* both false unless all contemporaneous tendencies in ethics are in a wrong direction.*

* There is one basis upon which both views may be logically held—total depravity. It may then be assumed that the child knows the rigl t in advance, but can be got to *do* it on'y through punishment.

The gap between theory and practice comes out also in the great reliance placed upon religious motives in the moral life. It is not necessary to enter into controversial questions here. The fact is enough that contemporary moralists, almost without exception and including all schools, hold that the reasons and duties of the moral life either lie within itself, or at least may be stated by themselves without direct reference to supernatural considerations. In running over the names of moral theorists of the present day, of all schools, I can think of but two exceptions to this statement. Sidgwick holds that it *may* be impossible to get a *final* statement of morals without postulating a supreme moral Being and Ruler, while Martineau holds that obligation is derived from such a Being. But even Martineau holds that the *facts* of obligation may be found directly in human nature; that it is only when we demand a philosophical explanation of its *nature* that we bring in the reference to God. Either, then, theory is working in a very unpractical direction, or else much of practice is going on in very anti-scientific fashion. A readjustment is demanded.

This brings me to my final point. An influential movement of the present times (I refer to the ethical culture movement) holds, as I understand it, that it is possible to separate the whole matter of the moral education of children and adults from theoretical considerations. With their contention that education can be (must be, I should say) separated from dogmatic theories I am heartily at one; but as, after all, a dogmatic theory is a contradiction in terms, the question is, whether such an emancipation can be effected without a positive theory of the moral life. It is a critical and practical question with every teacher and parent: What reasons shall I present to my child for doing this right act? What motives in him shall I appeal to in order that he may realize for himself that it is right? What interests in him shall I endeavor to evoke in order to create an habitual disposition in this right direction? I fail utterly to see how these questions can be even approximately answered without some sort of a working theory. To give a reason to a child, to suggest to him a motive—I care not what—for doing the right thing, is to have and use a moral theory. To point out its consequences to himself in the ways of pains and pleasures; to point out its reaction into his own habits and character; to show him how it affects the welfare of others; to point out what strained and abnormal relations it sets up between him and others, and the reaction of these relations upon his own happiness and future actions—to point to any of these things with a view to instilling moral judgment and disposition is to appeal to a theory of the moral life. To suppose that the appeal to do a thing simply because it is right does *not* involve such a theory; to suppose that the practical value of this

appeal must not itself be submitted to investigation and statement—to theory—strikes me as decidedly naïve.

Here as elsewhere our greatest need is to make our theories submit to the test of practice, to experimental verification, and, at the same time, make our practice scientific—make it the embodiment of the most reasonable ideas we can reach. The ultimate test of the efficacy of any movement or method is the equal and continuous hold which it keeps upon both sides of this truth.

A FAMILY OF WATER KINGS.

By Prof. CLARENCE M. WEED.

THERE is, perhaps, no way in which one can obtain a more vivid idea of the intensity of the struggle for existence among organic beings than by the study of the inhabitants of a fresh-water pond of long standing. Every inch of space in such a situation is teeming with life, both animal and vegetable, and the chief delight of most of the animals present is to wage a ceaseless warfare upon their weaker fellows. It is an aquatic rendition of Edwin Arnold's aërial drama:

> " . . . Then marked he, too,
> How lizard fed on ant, and snake on him,
> And kite on both; and how the fish-hawk robbed
> The fish-tiger of that which it had seized;
> The shrike chasing the bulbul, which did hunt
> The jeweled butterflies; till everywhere
> Each slew a slayer and in turn was slain,
> Life living upon death. So the fair show
> Veiled one vast, savage, grim conspiracy
> Of mutual murder, from the worm to man,
> Who himself kills his fellow."

The largest insects occurring in our fresh-water ponds are the giant water bugs—a family of peculiar creatures, armed with immense front legs fitted for grasping and clasping their victims, and a piercing, dagger-like beak which serves both to strike the prey and as a sucking tube to extract its juices, and which also appears to be provided with poison glands which make more sure the effect of every thrust.

Three species of these bugs occur in the Northern United States. Two of them are very large and closely resemble each other; the third is much smaller, less than half the size of the others. The commoner of the larger ones in the more northern States is represented natural size in Fig. 1. It is called by entomologists *Belostoma americana*, or the American belostoma. It is

brown in color, with leathery wings overlapping each other on its back; thick legs, along the sides of which are fringes for swimming; and a flat, boat-shaped body which offers little resistance to the water.

The eggs of the American belostoma are deposited on pieces of wood or reeds along the margins of ponds, apparently where they will be wet but not directly in the water. They are laid in clusters of from forty to sixty or more in each. The eggs themselves are about one fifth of an inch long, oblong-ovate in form, with the general color brown spotted with black; they are lighter colored below than above, and there is a whitish crescent near the top with a distinct black spot in its apex. This crescent indicates the margins of a little cap which comes off when the young bugs hatch.

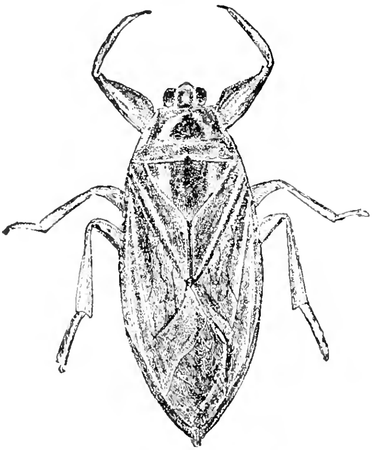


Fig. 1.—American Belostoma.

Little seems to be known concerning the early history of these bugs. They probably crawl into the water soon after hatching, and live upon such aquatic insects as they are able to catch. I do not know just how fast they grow, but presume they become full grown in a year. During the earlier period of their existence they have no wings; they are then in what the naturalists call the nymph state. Their appearance just before they become adult is represented in Fig. 2. It will be seen that they have no wings, but otherwise they very much resemble the full-grown bugs. Finally, the skin splits open along the middle of the back, and the insect crawls out of its old skin clothed in a new one which is provided with wings. It now for the first time can leave the pond where it has developed, and fly away to other bodies of water.

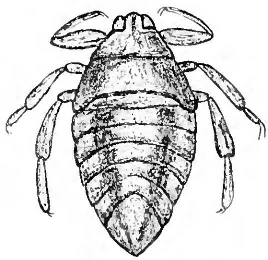


Fig. 2.—Last Stage of Nymph.

If the front leg of a full-grown American belostoma be examined carefully, there will be found on the front margin of the long joint nearest the body a longitudinal groove for the reception of the next joint. By this character the present species can always be distinguished from the other one, in which there is no groove. This latter insect is called *Belostoma griseus*. It is usu-

ally a little larger and darker colored than its American cousin, and apparently is more common southward than at the North. The life histories of the two species, so far as we know them, appear to be very similar. The eggs of the southern form are laid in masses on sticks or other rubbish at the margins of ponds. The general color of recently laid specimens is greenish brown, with longitudinal stripes of darker brown, and a faint indication of a light crescent near the top. Their bases are glued to each other and to the stick on which they are deposited by a sort of mucilage. An idea of the appearance of these eggs may be obtained from Fig. 3.


FIG. 3.—EGGS.

In South America a still larger species is found; it is called *Belostoma grande*, or the great belostoma. Still other species occur in Central America and Cuba, China and India, Egypt and Africa, but none are found in northern Europe.

Wherever these bugs appear they are formidable enemies of small fishes, frogs, and other aquatic animals. Of the *Belostoma griseus*, Prof. Uhler writes: "Developing in the quiet pools, secreting itself beneath stones or rubbish, it watches the approach of a mud-minnow, frog, or other small-sized tenant of the water, when it darts with sudden rapidity upon its unprepared victim, grasps the creature with its strong, clasping fore legs, plunges its deadly beak deep into the flesh, and proceeds with the utmost coolness leisurely to suck its blood. A copious supply of saliva is poured into the wound, and no doubt aids in producing the paralysis which so speedily follows its puncture in small creatures." In the breeding ponds of the Massachusetts Fish Commissioners these bugs destroyed so many young fish a few years ago that the authorities had to take special pains to catch and kill them.

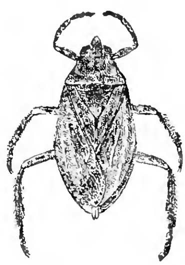


FIG. 4.—RIVER ZAITHA.

In many localities these insects have lately received the popular name electric-light bugs, because they fly so freely to electric lights. This indicates that in going from pond to pond they are nocturnal.

There is another species belonging to this family which is common throughout most of the United States. It is less than half the size of those we have been discussing, and is called by entomologists *Zaitha fluminea*, or the river zaitha; and is also known as the lesser water bug. It is a brown insect of the size and shape shown in Fig. 4. Its legs are provided with fringes for swimming, and it has a slender, sharp-pointed beak. As one would expect, it feeds on smaller animals than do the belostomas. A few years ago I dredged a number of these bugs out of an Ohio pond,

together with a great quantity of other forms of pond life, and placed them all in glass aquaria to study their feeding habits. The bugs seemed to feed most voraciously upon the larvæ or nymphs of dragon flies. These were captured continually, and their juices greedily sucked out. The next most abundant victim was the common undulating backswimmer (*Notonecta undulata*) shown in Fig. 5. In one aquarium, in which a large amount of pond material, including half a dozen zaithas, had been placed, four of the latter were in sight at one time, each with one of these backswimmers grasped in its front legs and the beak inserted in the body.

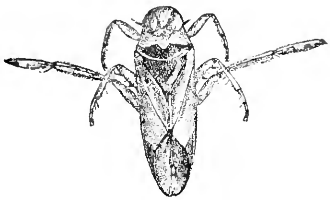


Fig. 5.—Undulating Backswimmer.

Small fresh-water snails occasionally contribute to the diet of this insatiable creature, and young mayflies are also commonly eaten. Flying insects which fall upon the surface of the water are sometimes caught and killed.

The giant water bugs are typical examples of the true bugs. They belong to the group called by naturalists *Heteroptera*, the members of which are characterized by having two pairs of wings, the front pair being thickened at the base and thin at the tip, and mouth parts fitted for sucking rather than for biting. During their development they do not undergo so complete a series of changes as do the caterpillars, which transform into butterflies, but grow more like the grasshoppers, the young resembling the adults in general appearance but having no wings. These bugs can be dipped out of ponds and ditches almost anywhere by means of a net, and are easily kept in aquariums, where they form interesting objects for study.

Illustrating, in one of his juvenile lectures, the liquefaction and solidification of gases, Prof. Dewar said that ether is evaporated to produce, by abstraction of heat from the gas, solid carbonic acid, which, though a white substance like snow, is boiling at 80° C. below zero. If the pressure is reduced by the air-pump, it boils at a lower temperature, and —110° C. may thus be reached. This is sufficient to liquefy nitrous oxide, which boils at —90° C.; and liquid nitrous oxide under the air-pump produces cold enough to liquefy ethylene, which boils at —100° C. The last stage is to liquefy air under pressure by the cold made by evaporating ethylene. In practice all these stages are not used, but they illustrate the gradational method which must be employed. The lecture was illustrated by liquid air being handed round in a flask inclosed in a vacuum jacket; though at a temperature of —180° C., it was boiling gently away. An idea was given of the difference between its temperature and that of the room by dropping it on a cold metal plate, when it assumed the spheroidal state like water on hot iron.

HUMAN AGGREGATION AND CRIME.

By M. G. TARDE.

UNTIL our own days, through that crisis of individualism which has prevailed since the last century, crime has been regarded as the most essentially individual thing in the world; and the notion of what might be called undivided crime was lost among criminologists, as was that also of collective sin among theologians. Whenever the attempts of conspirators or the exploits of a band of robbers forced the recognition of the existence of crimes committed collectively, the criminal nebulosity was promptly resolved into distinct individual offenses of which it was regarded as only the sum. But now the sociological or socialistic reaction against this great egocentric illusion is turning attention toward the social side of acts which are mistakenly attributed to the individual. Hence curious inquiry has been directed to the criminality of sects—concerning which nothing is more profound than M. Taine's labors on the psychology of the Jacobins—and, more recently, to the criminality of mobs. These are different species of the same genus; the criminality of the group; and the study of them together may be useful and opportune.

The difficulty is not to find collective crimes, but to discover crimes which are not collective, which do not involve in some degree the complicity of the surrounding. So much is this so that we may well ask whether there are any crimes really individual, the same as we doubt whether there are any works of genius that are not a collective result. Analyze the mental state of the most vicious and most isolated malefactor, at the moment of his deed; or that of the most enthusiastic inventor at the hour of his discovery; and having subtracted from it all in the make-up of his feverish condition which comes from education, companionship, apprenticeship, and the accidents of life—what is left? Very little; yet something, perhaps something essential, which does not need to be isolated to be itself.

Nevertheless, it is permissible to denominate individual crimes any acts performed by a single person under the operation of vague, distant, and confused influences of some indefinite and indeterminate other one; and we may reserve the epithet collective for acts brought about by the immediate and direct collaboration of a limited and precise member of coexecutants.

There are, indeed, in this sense, individual acts of genius; or, rather, there is the quality of individuality only in case of genius. For, it is remarkable that while morally, collectivities are susceptible of the two contrary excesses of extreme criminality and ex-

treme heroism, they are not so intellectually; and while they may descend to depths of folly or imbecility impossible to the individual taken by himself, elevation to the supreme display of intelligence and imagination is interdicted to them. They can, morally, fall very low or rise very high; but intellectually they can only fall very low. While there are collective crimes, of which the individual alone would be incapable—assassinations and pillages by armed bands, revolutionary fires, epidemics of venality, etc.—there are also collective achievements of heroism in which the individual rises above himself—charges of the legendary six hundred, patriotic revolts, epidemics of martyrdom, etc. But there are no collective acts of genius that can be contrasted with these. What discovery, invention, or real initiative within historical times has been due to that impersonal being, the public? Does one say revolutions? Not they; what revolutions have accomplished in pure destruction, the public may claim partly at least: but what have they founded and introduced that was novel that was not conceived and thought out before them or after them by superior men like Luther or Napoleon? Can any one cite an army, however well constituted, from which an admirable or even passable plan of campaign has sprung? Or even a council of war, which for the conception—I will not say the discussion—of a military manœuvre was worth the brain of the most ordinary general in chief? Was ever an immortal work in art, a painting, a sculpture, an architectural design, or an epic poem, imagined and wrought out by the collective inspiration of ten or a hundred poets or artists? All that is of genius is individual, even in crime.

To what is this signal contrast due? Why is the grand display of intelligence refused to social groups, while a large and strong display of will and even of virtue is within their reach? It is because the act of most heroic virtue is a very simple matter in itself, and differs from the act of ordinary morality only in degree. The power of unison in human assemblages, where emotions and opinions re-enforce one another rapidly by their multiple contact, is surely irresistible. But the work of genius or of talent is always complicated and differs in nature—not in degree only—from an act of ordinary intelligence. The question in a regular process is not, as in this, one of perceiving and recollecting at random, but of dealing with known perceptions and images in new combinations. At first sight it seems that ten, a hundred, or a thousand heads together are better fitted than one alone to embrace all the sides of a complex question. Peoples of all times, acting under this illusion, have looked to religious or political assemblages for the mitigation of their troubles. In the middle ages, councils—in modern times, states-general, par-

liaments—have been the panaceas demanded by suffering multitudes. The superstition of the jury is the offspring of a similar error, always mistaken and constantly reviving. In reality these bodies were never simple meetings of persons, but rather corporations like certain great religious orders or certain great civil or religious organizations, that have at times responded to the wants of the people. Still it should be observed that, even under their corporative form, collective bodies have shown themselves impotent to create anew. This is the case, however smoothly working may be the mechanism in which they are adjusted and geared. For how is it possible to match in simultaneous complication and elasticity the structure of that cerebral organism which every one of us bears in his head ?

As long, therefore, as a well-organized brain excels the best-constituted parliament in rapid and sure performance, in the prompt absorption and elaboration of multiple elements, and in the intimate solidarity of innumerable agents, it will be puerile, however plausible it may seem *a priori*, to count on mass meetings or on deliberative bodies, rather than on one man, to deliver a country from a difficult situation. In fact, every time a nation passes through one of those periods when it has an imperious need of great mental capacity as well as of great heart movements, the necessity imposes itself of a personal government, whether under the form of a republic or of a monarchy, or under color of a parliament.

The preceding considerations may be of use in determining wherein lies the responsibility of leaders for acts committed by the groups which they direct. An assembly or association, a mob or a sect, has no other thought than the one that inspires it; and it matters not that this thought, this more or less intelligent indication of an end to be pursued or of a means to be employed, is propagated from the brain of one to the brains of all—it continues the same. The one who inspired it is therefore responsible for its direct effects. But the emotion associated with this idea, and which is propagated along with it, does not continue the same as it spreads, but is intensified in a sort of mathematical progression; and what may have been a moderate desire or a halting opinion with the instigator—with the first whisperer of a suspicion, for example, ventured against a category of citizens—promptly becomes passion and conviction, hatred and fanaticism in the fermentable mass into which the germ has fallen. The intensity of emotion that moves the throng and carries it to excess, in the good or evil it does, is therefore largely its own work, the effect of the mutual warming up of those souls in contact by their mutual reflection; and it would be as unjust to impute to any one director all the crimes to which this over-excitement may

carry it, as to attribute to him the whole merit of the great deeds of patriotic exaltation and of the great acts of devotion excited by the same fever. We may, therefore, always hold the chiefs of a band or a riot accountable for the astuteness and dexterity it displays in the execution of its maneuvers, robberies, and acts of incendiarism, but not always for the violence and extent of the evils caused by its criminal contagions. The general alone is entitled to credit for the plan of the campaign, but not for the bravery of his soldiers. I do not say that this distinction is adequate to simplify all the problems of responsibility raised by our subject, but it will be well to regard it in trying to solve them.

From the intellectual as well as from other points of view, considerable differences may be established between the various forms of social groups. We do not include those which consist in a simple material bringing together of people. Passers in a thronged street, travelers meeting or thrown together on a packet boat, in a railway carriage, or around a dinner table, silent or without general conversation with one another, are grouped physically, not socially. As much may be said of countrymen congregated at a fair, as long as they do nothing but trade with one another, seeking each his own objects, even though they be alike, without co-operation in any common act. All that can be said of this sort of folk is that they bear in themselves the potentiality of a social group, so far as resemblances of language, nationality, religion, class, or education may dispose them to associate more or less closely, if occasion should require. Should an explosion of dynamite take place in the street, the vessel be in danger of foundering, the train run off from the track, a fire break out in the hotel, or a rumor about some forestaller spread through the market, the associable individuals would at once become associates in the pursuit of an identical purpose under the dominion of an identical emotion.

Thus may arise spontaneously the first stage of the association which we call the mob. By a series of intermediate steps there is raised from this rudimentary, fugacious, and amorphous aggregation, the organized, chief-led, persistent, and regular mob, which may be called the corporation, in the widest sense of the word. The most intense expression of the religious corporation is the monastery; of the lay corporation, the regiment or the workshop. The widest expression of the two is the church or the state. It may indeed be remarked that churches and states, religions and nations, are always tending, in their period of robust growth, to realize the corporative type, monastic or regimental, without, fortunately, ever quite reaching it. Their historical life is passed in oscillating from one type to the other; in giving the impression by turns of a great mob, like the Barbary States, or of

a grand corporation, like the France of Saint Louis. It was the same with what were called corporations under the old system of institutions; they were less corporations in the usual sense than federations of shops, these last very small corporations, each in itself authoritatively ruled by a patron. But when a common danger prompted all the workmen of the same branch of industry to unite for a common end, such as the gaining of a suit, just as all the citizens of a nation would unite in war time, the federative bond was closed up at once, and a governing personality was revealed. In the intervals between these unanimous co-operations, the association confined itself, in the associated shops, to the pursuit of a certain æsthetic or economical ideal, as in the intervals between wars the cultivation of a certain patriotic ideal constitutes the national life of citizens. A modern nation, under the prolonged action of leveling ideas, tends to become again a grand complex mob, directed to a greater or less extent by national or local leaders. But the necessity for hierarchical order in these enlarged societies is so imperious that by a paradox, the more remarkable as they are more democratic, they are often forced to become more and more military.

Between the two extreme poles which I have just marked may be placed certain temporary groups, recruited according to a fixed rule or subjected to a summary regulation, like the jury; or habitual meetings for pleasure, such as a literary *salon* of the eighteenth century, the court of Versailles, or a theater audience, which, although their object and common interest are trivial, accept a rigorous etiquette and a fixed hierarchy of different stations; or scientific and literary conferences—academies—which are rather collections of coexchangeable talents than groups of colaborers. Among the varieties of the species corporation may be named conspiracies and sects, which are sometimes criminal. Parliamentary assemblies are entitled to a place by themselves; they have more of the nature of mobs, complex and contradictory mobs—double mobs, we might say, as we speak of double monsters—in which a tumultuous majority is opposed by a minority or a coalition of minorities, and in which, consequently and fortunately, the evil of unanimity, that great danger of mobs, is partially neutralized.

Mob or corporation, however, all the species of true association have this identical and permanent characteristic, that they are produced, and led to a greater or less extent, by a chief, apparent or hidden; most frequently hidden in the case of mobs, but always apparent and obvious in corporations. From the moment when a mass of men begins to vibrate with an identical tremor, takes life and advances toward its end, it may be assumed that some guiding spirit or leader, or a group of leaders and moving spirits,

among which one is the active ferment, has infected it with his intense and perverted enthusiasm. As every shop has its director, every convent its superior, every brigade its general, every assembly its president, every fraction of an assembly its leader, so every lively saloon has its Coryphæus of conversation, every riot its chief, every court its king, prince, or princelet. If a theater audience can ever properly be regarded as constituting to a certain extent an association, it is when it applauds, because it follows, in clapping, the impulse of an initial applause; and when it is listening, because it yields to the suggestion of the author as expressed by the mouth of the actor who is speaking. Everywhere, then, whether visible or not, there reigns here the distinction between leader and led, so important in fixing responsibility. This is not saying that the wills of all are annihilated in the presence of the will of one; this, too, suggested, the echo of external or anterior voices of which it is only the original condensation—is obliged, in order to impose itself on the others, to make them concessions, and to flatter them in order to lead them. Thus it is with the orator, who has to take care not to neglect oratorical precautions; with the dramatic speaker, who has constantly to bend to the prejudices and changing tastes of his audiences; and with the leader who would manage his party.

Yet the conditions are various according as spontaneous or organized assemblies are in question. In the latter a will to be dominant must arise conformed, in a certain degree, to the tendencies and traditions of the prevailing wills; but once arisen, it executes itself with a fidelity the more perfect the wiser the organization of the body. In mobs an imperative will does not have to conform itself to traditions that do not exist, and may even get itself obeyed, notwithstanding its weak agreement with the tendencies of the majority; but, whether conformed or not, it is always imperfectly executed, and suffers changes in imposing itself. We can affirm that all the forms of human association are distinguished, first, by the way in which one thought or will among a thousand becomes the director of them under conditions of conflict of thoughts and wills from which it comes out victorious; second, by the greater or less facility which is offered in them for the propagation of the directing thought or will.

The objection has been made, with some force,* that the part

* A Russian economist made this objection at the Congress of Criminal Anthropology in Brussels, in August, 1892, citing agrarian risings in his country caused by the famine. More recently an Italian author, from whom we shall quote shortly, has made similar objections. On the other hand, I have learned, while correcting the proofs of this article, that the thesis developed in it has been previously set forth by a distinguished Russian writer, M. Mikhailowsky, in 1882, in a publication entitled Otechestwannia Zapiski.

played by leaders has not, in mobs at least, had the universality and importance which we attribute to it. There are, in fact, mobs without an apparent leader. Famine prevails in a region; on every side the starving masses rise, demanding bread: no chief appears here, but spontaneous unanimity. Let us look a little closer. All these uprisings do not break out together; they follow one another like a powder fuse, beginning with a primary spark. A first riot took place somewhere, in a place suffering more and more effervescent than the others, more exploited by agitators, apparent or secret, who gave the signal for revolt. The outbreak was then imitated in neighboring places, and the new agitators, thanks to their predecessors, had less to do; and from vicinage to vicinage, from mob to mob, their work is propagated with an increasing force that detracts correspondingly from the efficiency of local directors; till at last, particularly after the popular cyclone has spread beyond the bounds where there is any reason for it, or beyond the region of scarcity, no direction can be perceived. Strangely, indeed, to those who do not comprehend the force of imitative enthusiasm, the spontaneity of the uprising then becomes more complete the less motive there is for it.

Taken in one view, all the tumultuous assemblages which proceed thus from an initial riot in intimate connection with one another—a habitual phenomenon in revolutionary crises—may be regarded as a single mob. There are thus complex mobs, as in physics there are complex waves, chains of groups of waves. Placing ourselves at this point of view, we see that there is no mob without leaders; and we perceive, further, that from the first of these compound mobs to the last the function of the secondary leaders goes on diminishing and that of the primary leaders increasing, augmented at each new tumult born of a preceding tumult by a kind of distant contagion. Epidemics of strikes are a proof of it; the first that breaks out, the one therefore where the grievances are most serious and which consequently should be the most spontaneous of all, always leaves defined behind it the personality of the agitators; those that follow, often without the shadow of a reason, have the appearance of explosions without a match. It thus often happens that a mob started by a nucleus of excited persons goes beyond them, absorbs them, and, becoming headless, seems to have no leader. The truth is that it has none in the same way that raised dough has no yeast. The function of these leaders is, finally and essentially, greater and more distinct in proportion as the mob acts with more concentration, consecutiveness, and intelligence, as it comes nearer to being a moral person, an organized association.

It appears, then, that in every case, notwithstanding the im-

portance attached to the character of its members, the association, as a whole, is worth what its chief is worth. His character is the factor of pre-eminent importance; a little less, it is perhaps true, in mobs; but in them, on the other hand, while a bad choice of a chief may not produce as disastrous consequences as in a corporative association, the chances in favor of a good choice are much less. Multitudes and assemblages, even parliamentary bodies, are quick to be infatuated with a fine speaker, with any stranger; but the *collegia* of ancient Rome, the churches of the early Christians, all corporations of every kind, when they come to elect their prior, their bishop, or their syndic, have long been accustomed to examine into his character; or, if they receive him all fitted out, as in an army, it is at the hands of an intelligent and well-informed authority. They are less exposed to "ring rule," for they do not live continually in a single body, but most usually in a dispersed condition that leaves their members, freed from the constraint of contacts, to be influenced by their own reason. Besides, when the excellence of the chief of a body has been recognized, he may die, but his acts will survive him; the founder of a religious order, canonized after his death, continues to act in the hearts of his disciples; and to the influence he exerts is added that of all the abbés and reformers who succeeded him, and whose prestige, like his, grows and is refined by distance in time; while the honest leaders of mobs *—for there are such—cease to act as soon as they have disappeared, and are more easily forgotten than replaced. Mobs obey men, living and present only, men of physical and corporeal prestige, never phantoms of ideal perfection, immortalized memories. As I have just mentioned in passing, corporations in their long existence, sometimes of several centuries, present a series of perpetual leaders, grafted, as it were, upon one another and complementing one another; another difference from mobs, in which there is at most a group of temporary and simultaneous leaders who reflect and aggrandize one another.

There are other differences. The worst leaders are liable to be chosen and endured by multitudes, and the worst suggestions of all that are offered to be adopted. This is because, first, the most contagious notions or ideas are those which are most intense; and, secondly, the most intense ideas are the narrowest and most

* In a conference on Industrial Conciliation and the Function of Leaders, held at Brussels in 1892, a very competent Belgian engineer, M. Weiler, illustrated the useful function which honest leaders—that is, as he expressed it, leaders of the profession, not leaders by profession—might fulfill in differences between employers and their workmen. He also spoke of the little desire which workmen show in these critical moments to see "Messrs. the politicians" come up. Why? Because they know very well that, once come, these gentlemen will subjugate them with or without their consent. It is a fascination they are afraid of, but are nevertheless subject to.

false, striking the senses and not the mind, and the most intense emotions are the most egotistical. This is why it is easier in a mob to propagate a puerile fancy than an abstract truth, a comparison than a reason, faith in a man or suspicion of him than attachment to a principle or renunciation of a prejudice; and why the pleasure of vilifying being more lively than the pleasure of admiring, and the sentiment of preservation stronger than that of duty, hootings are more easily started than bravoes, and spasms of panic are more frequent than impulses of courage.

It has been remarked * that mobs are generally inferior in intelligence and morality to the average of their members. Not only is the social compound in this case, as it always is, dissimilar to the elements of which it is the product or combination rather than the sum, but it is also habitually worthless. This is true, however, only of mobs and aggregations that resemble them. But where the spirit of the organization (*esprit de corps*) rather than the spirit of the mob prevails, it usually happens that the composite, in which the genius of a grand organizer survives, is superior to its existing elements. Accordingly, as a company of actors is a corporation or a mob—that is, as it is more or less trained and organized—its members will play together better or worse than when separately they speak monologues. In a highly disciplined body, like the police, excellent rules for hunting criminals, hearing witnesses, and drawing up processes are transmitted traditionally, and fortify the mind of the individual in its reliance on a higher reason. While we can say with truth, adopting a Latin proverb, that senators are good men and the senate is an unruly beast, I have had a hundred occasions to remark that the *gendarmes*, though generally intelligent, are less so than the *gendarmerie*. A general made the same remark to me while drilling his recruits. Questioned separately concerning military maneuvers, he found them all stupid; but when they were brought together he was surprised to see them perform with a harmony and spirit, with an air of collective intelligence, very superior to what they had shown singly. The regiment, therefore, is often braver, more generous, and more moral than the soldier. Doubtless, corporations, whether regiments, religious orders, or sects, go further than mobs both in mischief and in well-doing; from the best disposed mobs to the most criminal is a less distance than from the noblest exploits of our armies to the worst excesses of Jacobinism, or from the Sisters of St. Vincent de Paul to the Camorrists and the anarchists; and M. Taine, who has depicted with much vigor criminal mobs and criminal sects, has shown that the latter were more mis-

* See, on this subject, a very interesting essay by M. Sighele, on La Folla delinquente, which has been reviewed by M. Cherbuliez in the Revue des Deux Mondes.

chievous than the former. But while mobs more frequently do ill than good, corporations more frequently do good than ill.

When, by chance, a multitude in action appears to be better, more heroic, and more magnanimous than the average of those who compose it, the fact is either due to extraordinary circumstances, or the magnanimity is only apparent and fictitious, and is the deep-seated result of a hidden terror. The heroism of fear is frequent in mobs. Sometimes the beneficent conduct of a mob is simply a survival of the custom of an ancient corporation. Is not this the case in the spontaneous self-devotion which is sometimes exhibited in the crowds which in cities run to put out a great fire? I say *sometimes* of them, not referring to the body of the firemen, in whom these admirable traits are habitual and exhibited daily. The multitude around these, following their example, perhaps stimulated by emulation, show also a rare devotion, and confront a danger to save a life. But when we observe that these collections of the multitude are a traditional affair, that they have their rules and customs, that they portion out duties, that the full buckets go round on the right and the empty ones on the left, that their actions are combined with a customary act rather than being spontaneous, we are brought to perceive that these manifestations of sympathy and of fraternal assistance have come down from the peculiar corporative life of the communities of the middle ages.

Instances in any number might be cited to illustrate how an excited multitude, even when the majority of it are persons of intelligence, has always something in it partaking both of the puerile and the bestial: of the puerile in the mobility of its humor, in its quick passage from rage to outbursts of laughter; of the bestial in its brutality. It is cowardly, too, even when composed of individuals of average courage. It is hard to conceive to what extent mobs, and unorganized, undisciplined collections of men in general, are more mobile, more forgetful, more credulous, and more cruel than the greater part of their elements; but the proofs of the fact are abundant. In the collective mind images succeed one another incoherently, as they do in the brain of a sleeping or a hypnotized man; while most of the individual minds which compose it, and which concur in forming that great folly called opinion, are capable of consecutiveness and order in the arrangement of their ideas. M. Delbœuf tells of a poor German, just arrived at Liége, who followed the crowd to the scene of a dynamite explosion. Some one, seeing him run a little faster than the others, pointed him out as the guilty person, and the whole mob was ready to cut him to pieces. Yet that mob was composed of the best society of the place, attending a concert; and gentlemen could be heard calling for a revolver

with which to kill recklessly an unhappy man of whose nationality, name, and crime they knew nothing.

When the cholera was raging in Paris in 1832, the report spread through the city rapidly that the disease was the work of poisoners, who, the people were brought to believe, were tampering with food, wells, and wines. Immense multitudes assembled in the public places, and every man who was seen carrying a bottle or a vial or a small package was in imminent danger of his life; the mere possession of a flask was sufficient evidence to convict, in the eyes of the delirious multitude; and many fell victims to its rage. Two persons, flying before thousands of madmen accusing them of having given a poisoned tart to children, took refuge in a guardhouse; the post was surrounded in an instant, and nothing could have prevented the murder of the accused men if two officers had not conceived the happy thought of eating one of the tarts in full view of the mob. The mob burst into laughter, and the men were saved. These follies are of all kinds, and the mobs are of every race and every climate—Roman mobs, charging Christians with the burning of Rome or the destruction of a legion, and throwing them to wild beasts; mobs of the middle ages, entertaining the most absurd suspicions against the Albigenses, the Jews, or any heretic, the spread of which was independent of proof; German mobs of Muzer in the Reformation; French mobs of Jourdan in the Reign of Terror—the spectacle is always the same. The inconsistency of mobs is illustrated by what Dr. Zambuco Pasha relates of certain Eastern villages where leprosy exists; where the populace are ready to chase any one suspected of having leprosy, and even to execute lynch law upon him; yet the same populace go to chapels attended by leprous persons, kiss the images they have kissed, and take the communion from the same chalices with them.

Mobile, inconsistent, and without real traditions as mobs are, they are, nevertheless, subject to routine; and in this they differ from corporations, which in their whole period of ascendency are traditionalist and progressive, and progressive because they are traditionalist. The power of routine over men casually brought together was curiously illustrated to me a few years ago at the rooms of a cure by inhalation at Mont Doré, where the three or four hundred men assembled to take the vapors issuing from a boiler in the middle of the apartment, having nothing to do or say, proceeded to march in procession around the room, and always walked in the same direction—that of the hands of a watch; and all efforts to start them in the opposite direction failed. An instance of the power of suggestion to start the crowd was furnished in a dissecting room, where the work could be carried on in the midst of conversation or singing. Some one would break

the silence by singing a measure or two of an air, and then stop. Instantly the strain would be taken up and carried on by another student working in another part of the room. The person who continued the song, when questioned on the subject, did not seem aware that he had followed any definite impulse. Is there not in this often unconscious suggestion something that casts a light on those ideas that come up, one knows not why or how, in mobs that come, no one knows whence, and spread with dizzy rapidity?

An audience in a theater suggests similar remarks. While it is the most capricious of publics, it is also the most sheeplike, and it is as hard to foresee its caprices as to reform its habits. Its ways of expressing approbation or blame are usually the same in the same country; then it must always be shown what it is accustomed to see on the stage, no matter how artificial it may be; and it is not safe to show it what it is not accustomed to see there. Still, it must be remembered that the theater audience is a seated mob—that is, only half a mob. The real mob—that in which electrification by contact reaches its highest point of rapidity and energy—is composed of people standing and, better yet, in motion. Yet the most effective agents of mutual suggestion, especially the sight, still exist among seated spectators; and, no doubt, if they did not see one another, if they were witnessing the play as prisoners in cells hear mass in little grated boxes whence it would be impossible to look around, each of them, influenced by the action of the piece and the actors, free from all mixture with the action of the public, would be more fully controlled by his own taste, and the applause or hissing would be much less unanimous. It rarely happens at a theater, a banquet, or any popular manifestation, that one—even if he at heart disapproves the applause, the toasts, or the hurrahs—dares to withhold his applause, or not to raise his glass, or to keep an obstinate silence in the midst of enthusiastic cries. At Lourdes, in the processional and praying throng of believers, there are skeptics who, on the morrow, thinking over all they have done to-day—the crossing of their arms, the expressions of faith uttered by some and repeated by all the others, and the prostrations—will jest about them. They will, nevertheless, not laugh or protest to-day, but will themselves kiss the ground, or pretend to, and if they do not actually hold their arms crossed, will make the gesture of it. They are not afraid, for there is no force in these pious throngs: but they do not wish to be scandalized. And what, at the bottom, is this fear of scandal except the extraordinary importance attributed by the most dissenting and most independent of men to the collective blame of a public composed of individuals, for the personal judgment of each one of whom he would not care a whit? This, however, is not always sufficient to explain the

habitual and remarkable condescension of the unbeliever to the fervent multitudes in which he is immersed. We must also, I believe, assume that at the moment when a wave of mystic enthusiasm passes over them he takes his little part of it and finds his heart traversed by a fugitive faith. This being admitted and explained for pious crowds, we have a right to explain in the same way what passes in criminal mobs, where a current of momentary ferocity sometimes crosses and denaturalizes a normal heart.

It is a trite piece of exaggeration to glorify civil courage at the expense of military courage, which passes for something less rare; but the truth there is in this trite idea is explained by what has just been said. Civil courage consists in resisting a popular enthusiasm, in going against a current, in uttering before an assembly or a council a dissenting, isolated opinion, opposed to that of the majority; while military courage consists, generally, in distinguishing one's self in battle, in yielding most completely to the environing impulse, and in going further than the others in the direction that one is urged by them. When, in an exceptional case, military courage requires one to resist an impulse, when a colonel has to oppose a panic, or to restrain the inconsiderate eagerness of troops, bravery of that kind is still more rare, and, let us acknowledge, is more admirable than an opposition speech in the legislative chamber.—*Translated for The Popular Science Monthly from the Revue des Deux Mondes.*

THE DISTRIBUTION OF GOVERNMENT PUBLICATIONS.

By Prof. EDWARD S. MORSE.

IF there is any one portion of government machinery that would seem to demand a readjustment it is that portion which has to do with the distribution of public documents. I am not aware that there is any central bureau for the judicious distribution of the various publications of Government as there is, for example, for the issuing of patents or the payment of pensions. There is no government in the world more generous in the distribution of its multifarious publications than ours. The niggardly way in which Great Britain doles out her public documents has repeatedly excited the most adverse criticism from her own people. Knowing, as every one does, the slightly increased expense of printing extra copies after the first expense of composition, engraving, etc., has been provided for, it is most exasperating to see a rich country like Great Britain publishing the

results of some important expedition, like that of the Challenger, for example, and not printing enough copies to meet even the hungry demand of her own special students. We have never erred in this respect, and in the scathing comments which this particular English frugality has received from her own men, our country has invariably been held up in striking contrast as an example to imitate. With the liberality of the General Government in this respect it is a pity that the distribution of printed matter should not be better systematized. There are many documents that doubtless represent official reports which are circulated not so much for instruction as to inform the country just what has been done by certain bureaus, and these probably reach the proper parties, in being sent to those prominent in governmental and political matters. With these we are not concerned. There are many other publications, however, that are issued solely for the purposes of information and instruction in lines of thought in which there are hundreds, perhaps thousands, of students in the United States. It is obvious that if these kinds of documents are issued to advance learning, then such copies, as are freely distributed through the mails should go to those who most need them. The present distribution of many of them is so imperfect that it would be paralleled by the Pension Bureau issuing a certain number of money checks to congressmen and senators to scatter where they pleased, or to realize on them if they were so inclined. Let me make this clearer. So far as I have been able to ascertain, the regular edition of a public document is nineteen hundred. From this edition fifty foreign governments, and the larger libraries and institutions in this country are each supposed to receive a copy. Each senator and congressman is entitled to two copies, and probably more for the asking. It is a common belief that many of these men dump their public documents into the waste-paper barrel, for the janitor to realize upon as old paper, which at one time had some value. As a matter of fact, many of them are sold to the junk shops, where they find their way into the secondhand book stalls; and students who want them are grateful for even this opportunity of securing them by purchase. It would certainly seem that a report which is of special interest to a greater or less number of students and writers should in some way get to them, and that their names should be on some permanent list at headquarters, so that when any report in their special line of thought is published they should be among the first to receive it. Not only is it evident that the Government publications often fall into the wrong hands, but, worse still, hundreds of thousands of volumes are rotting in the cellars of the Capitol and vitiating the air by their decomposition. A committee recently appointed by the

House, to look into the question of fresh air has just discovered that certain rooms in the basement of the Capitol are filled with Government publications. In one series of vaults were one million two hundred and fifty thousand volumes, and many of these have been stored for thirty years. "They present a vast bulk of decomposing vegetable matter, which is constaintly tainting the atmosphere with impurities."

One reason of the apathy of the people in regard to the waste of public documents is that being free they are supposed to be valueless, and to many who receive them they have no value. In the rural regions they are used as scrap-books by the children, and there is hardly an attic in the land that does not contain a few of this kind of books, mixed with the usual light truck which ascends to the garret.

There is certainly nothing to complain of in the scientific departments of the Government. The valuable contributions published by the various scientific bureaus, have been distributed in such a way that special students get, without much trouble, the works needed in their studies. So far as I know, but few if any of these drift into the wrong channels. There are special reports of an ethnological character now and then appearing in other departments, notably in the United States consular reports, and subjects pertaining to other sciences issued from other bureaus, and these would be priceless to certain special workers, yet such reports are usually exhausted when application is made for them. I have often secured Government publications of the greatest value by overhauling a lot of stuff which some lawyer was about to throw away. Reports that I had never heard the existence of have come to me in this manner. Lately I had given to me from an editor's room several shelffuls of pamphlets, books, etc., which were on their way to destruction. Among these were many public documents on various subjects, and these were distributed to those whom I knew would make good use of them. Among the letters of acknowledgment was one from a gentleman who has made a special study of the seal-fisheries dispute, and has written a number of reviews on the subject. This letter came in return for a government report containing a lengthy legal opinion about the seal fisheries, and is as follows: "Ever so much obliged to you for the document. I devoured it right off, and then took it up to the Harvard Law Library, where they were no less pleased to get it. They had never seen it nor heard of it, and seemed to be amused at the idea of their obtaining it through two such outside barbarians in law matters as you and I." This is by no means an exceptional case.

A public library of nearly forty thousand volumes in a neighboring city finds it impossible to get anywhere near a complete

set of current Government reports; and yet it is plain enough that all public libraries in the United States, no matter how small, should be entitled to receive such publications of the Government as bear on science, education, etc., provided they ask for them and indicate a willingness to provide shelf room.

It is also said that documents are distributed as political favors, and thus, during a change of administration, these currents flow in other directions. The power to scatter such documents should be entirely out of the hands of politicians, and a central bureau should be organized whose duty it should be to keep lists of all persons making researches in the various departments of science, law, education, etc. Senators and representatives might be empowered to furnish these names, accompanied by evidence, however, that such persons had a right to them by virtue of their studies or occupations.

I know as a fact that many who receive these reports and documents are actually burdened with them, and often throw them into the waste-paper basket unopened, and there are hundred of others who would like them, and would make good use of them, and yet never get them. All this might be corrected by some systematic way of distribution from a common center.

If I were permitted to offer suggestions upon a matter with which I can claim but little knowledge, I would ask first that for convenience of reference there should be published each year a volume containing a list of all Government publications, with at least a table of contents of each report, and if possible a brief synopsis of the more important papers. Students would then have an opportunity of finding out the material they were in quest of. In the same volume should also be given a classified list of the recipients of Government reports, and this list should be kept standing for additions and subtractions. This annual report could be printed in the most condensed form, the matter solid, the covers paper, etc. Such a report should find its way into every school, college, and public library in the United States and to every one applying for it. It should be as common as an almanac. A list of publications of this nature might possibly show what appears to many the disjointed character of some of the series and lead to simplification. The Government goes on forever, yet with every new chief of department or change of administration comes a new series of parts or volumes, to the misery and despair of bibliographers. The hungry ambition of species describers might be curbed by checking the issue of *separata* of one or two pages.

If it were possible to establish a separate bureau of distribution, it would lead to economy of administration, to the economical and efficacious distribution of reports, the avoidance of duplication, and consequently the placing of material where it would

do the most good, or at least where it would not be used to kindle the kitchen fire.

The above suggestions refer solely to those reports which tend to the advancement of human learning, and, printed and distributed freely as they are by the nation, should reach in every case those who stand most in need of them.

THE STORY OF A GREAT WORK.

By J. JONES BELL.

ON the 19th of September, 1891, Sir Henry Tyler, President of the Grand Trunk Railway Company, presided at the inauguration of one of the greatest engineering achievements of the present day, bold in conception, new in design, and novel in many of the methods adopted in its construction. Without the St. Clair Tunnel the immense stream of traffic from the East, which during last summer flowed to the World's Columbian Exposition at Chicago, could not have been successfully handled.

Previous to the construction of the tunnel, connection between the Grand Trunk Railway and the Western roads with which it exchanges traffic was maintained by a ferry, the loaded cars being carried across on the deck of a powerful steamer, specially built for the purpose. Adopted for want of a better, this service was never satisfactory. Though the swift current, where Lake Huron pours its entire volume through a narrow outlet, prevents the river freezing in winter, ice blocks occasionally occurred, and a single day's interruption to traffic involved serious inconvenience and loss. A bridge had often been suggested, but it was always successfully opposed by the vessel interest. A larger number of vessels, with a greater tonnage, pass up and down the St. Clair River during the season of navigation than through the Suez Canal in a year. A high-level bridge is impossible, and a draw would be attended with great interruption to traffic, and danger to vessels on account of the current. The only alternative seemed to be a tunnel. Its completion not only affords a better crossing, but establishes the possibility of such a work being successfully and economically built and worked where favorable conditions exist. The story of its construction is an interesting one.

The tunnel is really a large iron tube, twenty feet in diameter and six thousand and twenty-six feet long, buried under the river, but considerable ingenuity was required to place it there. In 1884 Mr. Joseph Hobson, the chief engineer of the work, and Mr. Hillman, his assistant, made a survey of the river, one mile be-

low the towns of Sarnia and Port Huron. Though not so narrow as where the cars were ferried, the nature of the bed of the river seemed to be more favorable at that point. Borings were made to the rock, eighty-six feet below the level of the river. The greatest depth of water was 40·47 feet. The bed of the stream was found to consist of the following layers: two feet of common yellow sand like that of the seashore, twelve feet of a mixture of quicksand and blue clay, twenty-one feet of blue clay of an adhesive and putty-like character and increasing in density, and then the rock. In 1886 a company was organized, and in January, 1889, the work was commenced. After various tests and experiments, necessary from the difficulty of boring through quicksand and clay under water, and near rock full of fissures from which natural gas escapes, two great excavating shields were started, one on each side of the river. Two cuttings were made, one on the Canada side fifty-eight feet deep, and one on the United States side fifty-three feet deep, into which the shields were lowered ready to begin their work. The shield on the United States side commenced on the 11th of July, that on the Canada side on the 21st of September. They met on the 30th of August, 1890, after traveling six thousand feet. The work had proceeded day and night, by the aid of the electric light, three gangs of men having been employed, in shifts of eight hours. Each shield averaged ten feet per day, and the most accomplished in any one day was twenty-seven feet and ten inches.

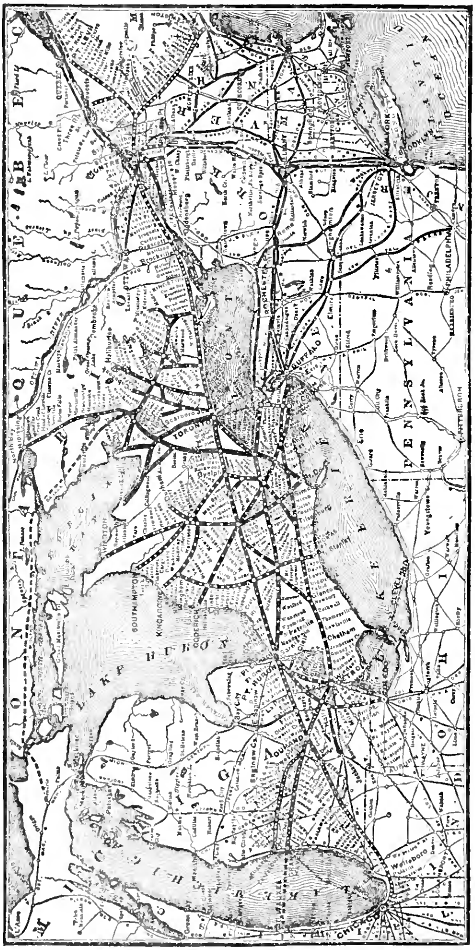


Fig. 1.

The tunnel could not have been built without this shield. The credit of its invention appears to be due to Mr. Alfred E. Beach, of New York, who designed it in 1868 for use in the construction of the tunnel under Broadway. It was subsequently used in Buffalo, Chicago, at the Hudson River Tunnel, and other places. The use of the shield in tunneling was first introduced by Sir Mark I. Brunel in 1825, and it was afterward employed by Mr. Greathead, in the Thames Tunnel and other works; but the St. Clair shield differs in some important respects from any before employed. It is a cylinder of iron, twenty-one feet and six inches in diameter and sixteen feet long, built of steel one inch thick, and with a sharp cutting edge in front. It is divided into twelve compartments by two horizontal and three vertical stays. It weighs fifty tons, and was built on the spot, the material having been prepared in the workshops at Hamilton. Against the rear end of the shield were ranged twenty-four hydraulic rams, eight inches in diameter and having a stroke of twenty-four inches. These forced the cutting edge forward into the clay, which was then excavated within the shield. By means of a Worthington pump, a pressure of five thousand pounds per square inch, or three thousand tons in all, could be exerted. The greatest pressure used was seventeen hundred pounds per square inch, or a thousand and sixty tons in all. The pressure could be exerted on any or all of the rams so as to preserve the true direction of the shield. The keeping of this direction was one of the interesting engineering feats of the work. It was done by means of a specially made London transit, set on masonry, a series of disks and cross-wires indicating the slightest deviation.

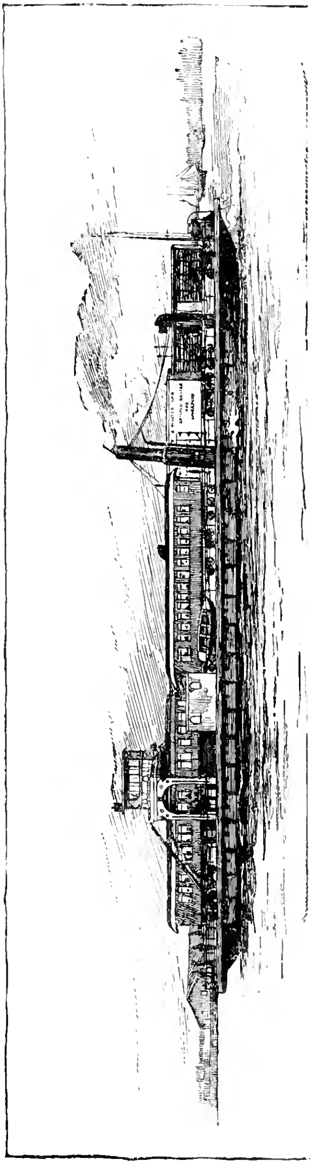


Fig. 2.—The Old Railroad Ferry.

Observations were made every day and the results marked on a diagram. The deviation was rarely found to exceed a quarter of an inch, and any error was corrected by adjustment of the hydraulic jacks. When the shields came together they were found to be exactly in line.

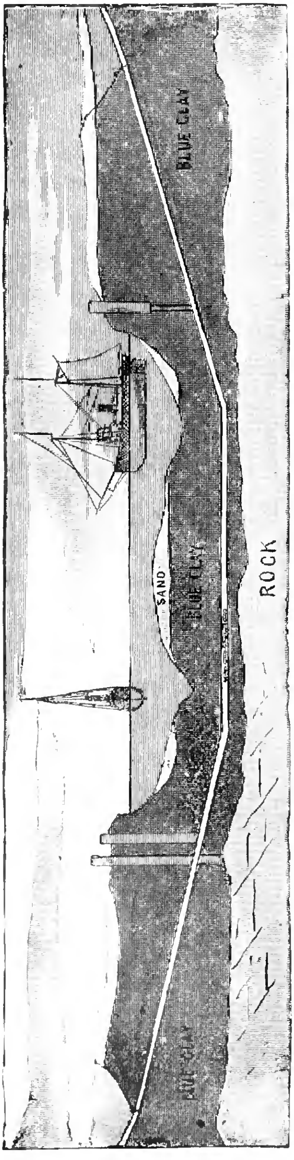


Fig. 3.—Line of Excavation of the St. Clair Tunnel.

At one time it was feared the work would have to be abandoned. When the tunnel from the Canadian end reached the bed of the river, quicksand and water caused much trouble, but by the use of compressed air the difficulty was surmounted. At the line of the river on each side a bulkhead of brick and cement was built across the tunnel, with two air chambers, provided with airtight doors. The greatest atmospheric pressure necessary to prevent an inroad of sand and water was thirty-seven pounds per square inch, and under this pressure, after a short experience, the workmen found no difficulty in pursuing their task, in half-hour shifts. The use of compressed air had to be resorted to at two points.

The completed tunnel, as already stated, is an iron tube. This tube is built up of rings, eighteen inches in width, one of which was put together within the shield each time it was moved forward. Each ring consists of thirteen sections and a keypiece, flanged to enable them to be bolted together. The body of the section is two inches thick, and the flanges are six inches wide. Each section weighs about one thousand pounds. The pieces were lifted and placed in position by a revolving crane, a complete ring being put up in about one hour. To ease the pressure and make the joints watertight, the edges were planed and strips of oak and tar canvas inserted. The sections were also heated and dipped in pitch. The tube being only twenty-one feet in diameter, while the shield was twenty-one feet

and a half, the space under the tube when the shield moved forward was filled with cement. The clay was allowed to settle down on the upper part. When the shields met, the tube was built up within them to the junction and the shells of the shields allowed to remain. The inside of the tube is finished with a preparation to keep it from rusting.

On Sunday, August 24, 1890, the two excavations had approached so nearly that an opening was made with an earth auger, and the workmen talked and passed articles to each other. The earth was soon removed, and Mr. Hobson, the chief engineer, and others connected with the tunnel company, stepped through. Six days later the shields came together and the success of the great undertaking was assured. In its construction about seven hundred men were employed, of more than average intelligence, who took great interest in the work.

The actual length of the tunnel, from portal to portal, is six thousand and twenty-six feet. Of this, two thousand three hundred and ten feet is under the river, one thousand nine hundred and eighty-two feet under dry ground on the Canada side, and seventeen hundred and thirty-four feet under dry ground on the United States side. The open excavation to reach the ground level on the Canadian side is three thousand and sixty-one feet, and on the United States side two thousand four hundred and sixty-six feet. The grade is one in fifty, except under the river, where it is practically level, only sufficient incline—one tenth per cent—being given toward the Canadian side to provide for drainage. The depth of the lowest part under the mean level of the river is 77·83 feet. The minimum depth between the top of the tube and the bottom of the river is fifteen feet, the average being twenty-five feet. It was necessary to place it as far down as possible in the clay, consistent with the grade, so as to overcome the tendency of a tube filled with air to rise to the surface in water or mud. The bottom is about nine feet above the rock which underlies the clay. On the Canada side the bottom is sixty feet below the surface of the ground at the portal, on the United States side it is eight feet less. The bottom of the tunnel at its lowest point is one hundred feet below the railway track on the level, which indicates the total ascent and descent which trains have to make in passing through. Ventilation is secured by the motion of the trains, which is found to be ample for the purpose.

The trains are drawn through the tunnel by powerful locomotives belonging to the tunnel company, specially built for the purpose. They take eighteen loaded cars at a trip.

The track in the tube is supported on solid brickwork, as shown in the accompanying cross-section. It was at first proposed to build the tunnel wide enough for two tracks, but it was found

that two single-track tunnels would be cheaper, and one of them would sooner be available for traffic. Experience has proved that a second tunnel will not be required for a long time. The largest number of freight cars passed through in twenty-four hours

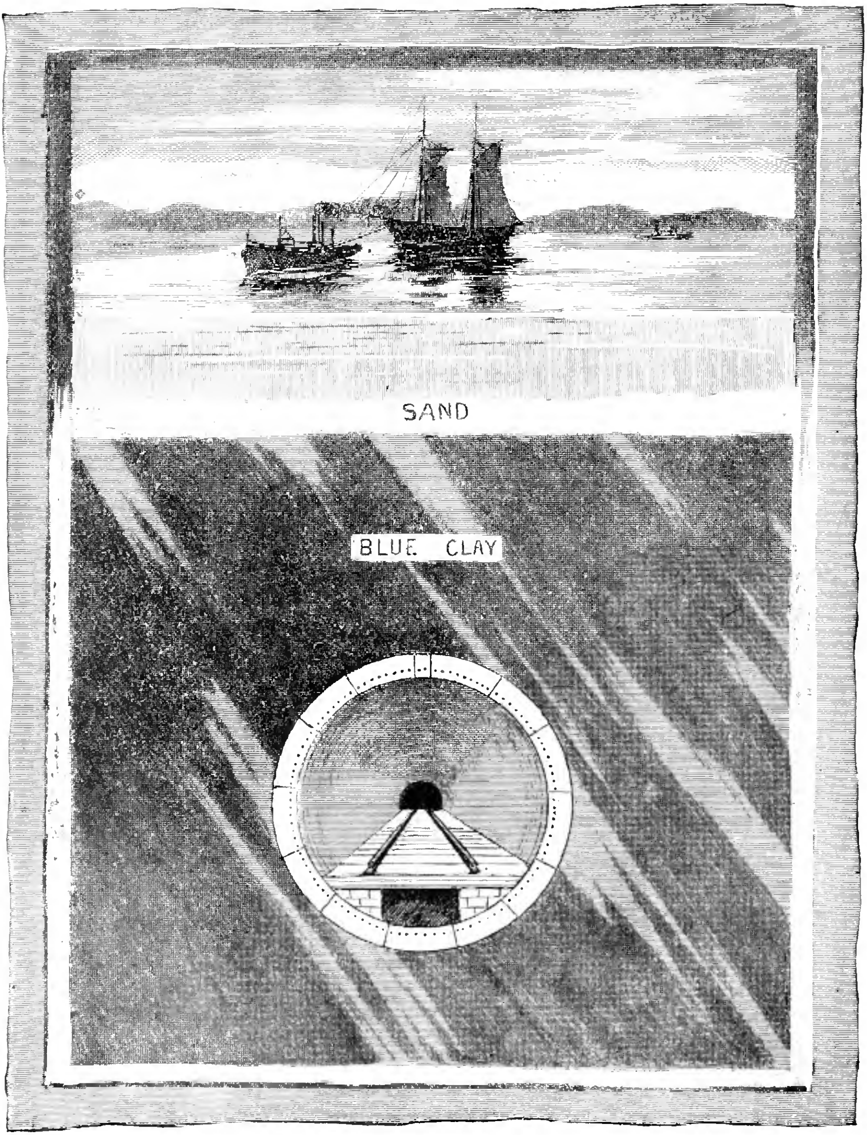


Fig. 1.—Section of the Tunnel and River-bed.

during the two years the tunnel has been in use was one thousand and fifteen, while twenty-five hundred could be handled if occasion required. The average number is seven hundred in

winter and five hundred in summer. This is in addition to passenger trains.

The estimated cost of this great work was between two and a half and three million dollars, but its actual cost was considerably less, a rather remarkable fact in connection with such works. Owing to the great risk any contractor would have to assume, and the large sum required to cover that risk, the work

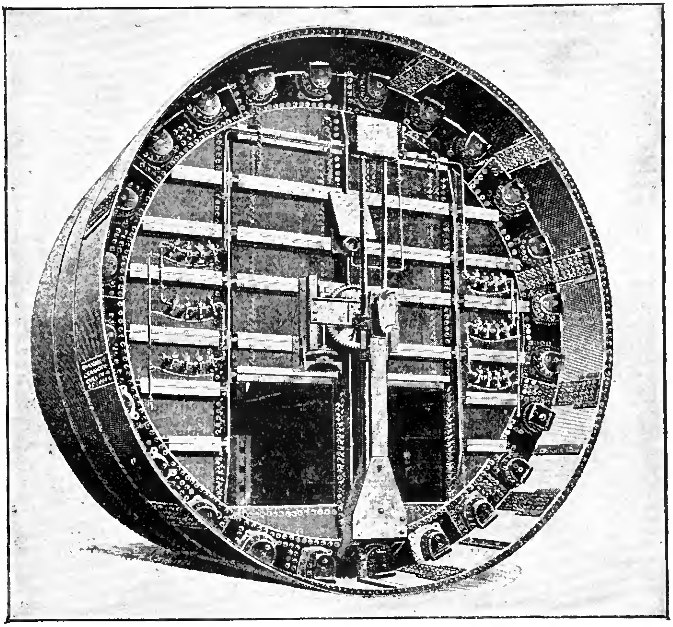


FIG. 5.—SHIELD USED IN THE TUNNEL EXCAVATION.

was performed by the company, only the material being contracted for.

The opening ceremonies were attended with much *éclat*, as became the completion of such a work, uniting not simply two towns but two nations, and rendering possible a greatly increased international trade when the tariff barriers which now stand in the way are removed. It was proposed to spread the banquet in the tunnel, beneath the waters of the St. Clair, with the Governor-General of Canada seated on one side of the international boundary line and the President of the United States on the other, but this part of the programme had to be abandoned. The banquet, to which three hundred guests sat down, after they had passed through and formally opened the tunnel, brought together a greater number of notable men in the world of science, literature, and politics than had ever before gathered in a similar manner in Canada.

Speaking of tariff barriers recalls the fact that the sections for the ends of the tube were made in different places—those for the Canada end in Hamilton, and for the United States end in Detroit—so as to avoid the payment of duty.

To Joseph Hobson, a native Canadian, is due, more than to any other man, the successful completion of this great work. He was its architect, designer, and builder, and though his proposals did not, at the outset, meet with much encouragement from engineers, the result fully justifies the confidence reposed in him by Sir Henry Tyler, President of the Grand Trunk; Sir Joseph Hickson, its former general manager; and Mr. Seargeant, Sir Joseph's successor, all of whom ably seconded Mr. Hobson. It is a fact worthy of note that Mr. Hobson received all his professional

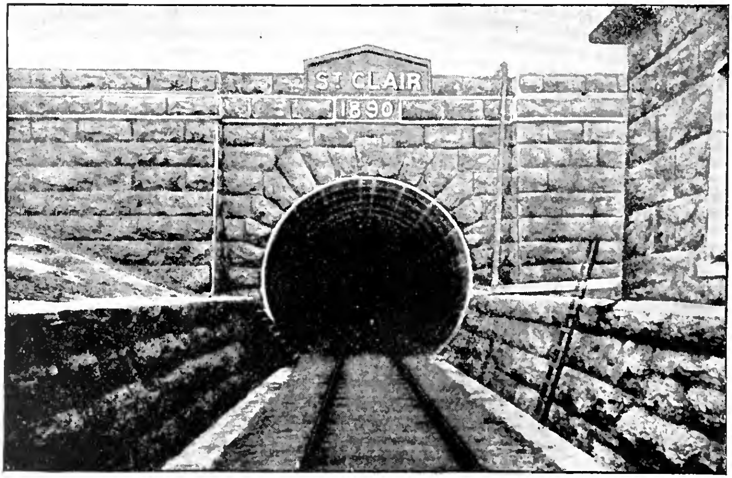


Fig. 6.—Entrance to Tunnel.

training on the continent of America, never having been farther east than the city of Quebec. He is a member of the Institutes of Civil Engineers of England, America, and Canada, and has established his right to rank among the first engineers of the world.

The successful completion of the St. Clair Tunnel will doubtless be followed by the construction of many similar works. In 1872, when the Great Western Railway of Canada—now a part of the Grand Trunk—was an independent line, tests were made for a tunnel under the Detroit River, and a drainage tunnel excavated for some distance. Quicksand was met, and, the shield and iron tube not having been adopted for tunnel work, it had to be abandoned. The project has been revived, and if, on fuller investigation, the conditions are found favorable and the work carried out,

there will be a tunnel over twelve thousand feet long and twenty-seven feet in diameter, to accommodate two tracks. The Michigan Southern has also been making tests at its crossing, a short

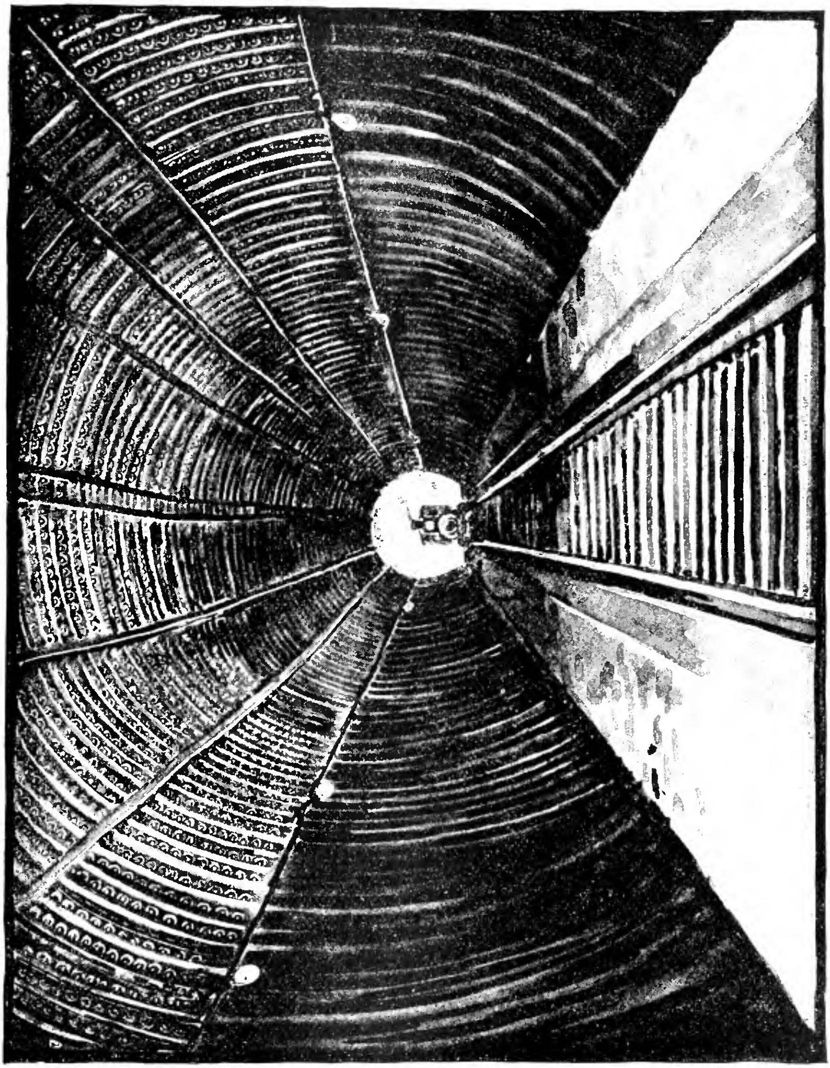


Fig. 7.—Interior of Tunnel

distance below Sarnia, but the strata are not favorable for tunnel construction.

One of the remarkable features in connection with the St. Clair Tunnel is the rapidity with which it was constructed. The average advance was 455·4 feet per month. Contrast this with the Thames Tunnel, three thousand six hundred feet long, which was commenced in 1825 and not completed until 1843, though work

was, it is true, suspended for a time. A curious incident, bearing on the rapidity of construction, is related. A cooper, who could not obtain work at his own trade, applied for employment, and was put with the excavators in the shield. He was not accustomed to the use of the spade or shovel, the drawknife being his tool. It was hard work digging the tenacious clay with a spade, the only effective tool in its removal being a long, narrow spade, such as tile-ditchers use in England. The next day the cooper appeared with a drawknife of semicircular form, about six inches across, and, despite the jokes of his fellow-workmen, set to work with it. It was soon found that he could shave away the clay much more rapidly than it could be dug out. All the workmen were soon provided with drawknives, and it is probable that tool has come to stay as a means of tunneling in sticky clay.

The accompanying illustrations will give an idea of the character, progress, and appearance of the work after completion.

A PROPOSITION FOR AN ARTIFICIAL ISTHMUS.

By ERNEST A. LE SUEUR.

A STUPENDOUS scheme has recently been seriously suggested for the utilization in British waters of the energy of ocean currents for the purpose of distribution of power and light by means of electricity to centers of population at distances up to hundreds of miles from the source. This is nothing less than the proposition to dam the Irish Channel at the Mull of Cantire, where the distance between the Scotch and Irish shores is only fifteen miles, and where the energy of the current from the north is, so far as human requirements go, infinite—that is, would have to be expressed in scores of millions of horse power.

That this proposition is being regarded with some degree of seriousness may be gathered from the fact that a series of hydrographic surveys of the bottom of the channel has been made and charts prepared of the coasts and of the highlands on both sides from which materials might be conveniently got for building the dam. The report of an engineer detailed for the purpose is to the effect that there are no engineering difficulties in the way; by which is meant that, given the means to proceed, it is a possible thing to do, and is, compared, for instance, with the erection of the Brooklyn Bridge, a piece of work requiring merely enough brute force.

The idea is not primarily to afford a land junction for purposes of easier communication—although, of course, if the dam were constructed, a railway would be laid across—but, as mentioned, to give

an opportunity of utilizing the tidal power. There is a continuous flow from the north (due in the first place to the Gulf Stream), estimated at between one and two hundred cubic miles per day. If a dam were thrown across, the effect would be to turn the Irish Sea into a bay and to bank the waters of the North Sea a number of feet higher on the north side of the dam than the level of the now Irish Channel on the south. From this difference of levels an unlimited quantity of power could be drawn. One can get a faint conception of the amount that would be on tap by comparing the case with that of the utilization of the energy of the Falls of Niagara. There is at present in course of construction at the falls a vast scheme of power development which will supply one hundred thousand horse power day and night all the year round. The amount of water which this will take will be insignificant compared with the total quantity going over the falls, which is roughly estimated at three hundred and fifty thousand tons *per minute*, and one hundred thousand horse power will be developed by about thirteen thousand tons per minute. The total power on the falls is thus some twenty-seven times the one hundred thousand horse power. This total quantity of water amounts to about one cubic mile every nine days, and the volume of water running through the Irish Channel is about one hundred and fifty cubic miles daily. Of course, the number of feet of fall is many times greater at Niagara than it would be at the proposed dam, but even so the total horse power available at the dam would be more than fifty times that of the whole of the Niagara Falls.

The site of the proposed undertaking is between the headlands of Antrim and Cantire. On both sides the ground is described as high, and on the Irish side there rise several peaks of considerable height, viz., from nine to twelve hundred feet. These are sufficiently near the shore to be used to dig materials from to be gravitated down to the dam, and the fact is of great importance in connection with reducing the expense of the work by doing away with the necessity for power for the traction of these materials.

The channel is, as has been said, some fifteen miles in width and of varying depth. The average depth is about three hundred feet, and the maximum is given by Mr. Lodian, in the Electrical Engineer of January 24th last, as four hundred and seventy-four feet; in many places it is as little as two hundred. The bottom is described as of "shells, stones, and rock," which would probably hardly settle at all under the weight of the dam. The current is six or eight miles an hour, varying somewhat at different points in the cross-section of the channel. The total quantity of material necessary to form the dam or isthmus would be in the neighborhood of five hundred million cubic yards. One can imagine that

this amount of material removed from the crowns of a few high hills in the vicinity would alter the landscape considerably, and that this alteration, together with the turning of the Irish Sea into a landlocked bay, might confuse a person acquainted with the locality only as it had been before the commencement of the work. The territory to be acquired for the land work would not be expensive, as the country on both sides is almost desert.

It is proposed to construct two generating plants near the two shores respectively, each to be used to supply the country to which it is nearest. In order not to interfere with navigation, it is suggested to enlarge the canal of Crinan and to make a cut through the isthmus of Tarbert. To the writer it does not seem that these means would be better than simply to cut through the dam and provide suitable locking facilities.

One of the remarkable results which, it has been pointed out, would flow from the construction of such an artificial isthmus is the lowering of the level of the Irish Sea along the east coast of Ireland, and thus rendering the marsh lands in that section capable of receiving a high degree of cultivation.

Besides the great interest that any such plan must have in itself, from the fact of the important change in the geography of the British Isles which it would bring about, the results that would flow from a utilization of a part of the tidal power for distribution throughout the kingdom are most impressive. Our means for the distribution of power electrically have developed, within the past year or two even, to an extraordinary degree. Two years ago it was possible to transmit electricity for lighting purposes a great number of miles from the point of generation, but it was not commercially possible so to distribute electricity for power purposes. The reason for this is that in order to have electricity in a safe form for use in houses, mills, or car lines it must be supplied at low voltage (or electrical pressure); on the other hand, if we are not to use an utterly prohibitive weight of copper conducting wire we must transmit at high voltage. What is done, therefore, is to transmit at, say, ten thousand volts and transform at the consuming end down to anywhere from five hundred to one hundred volts; the trouble is that there is no practical way of transforming direct currents, and until recently the alternating could not be used to work commercial motors. Now, however, due largely to the work of Mr. Nikola Tesla, we have motors that operate at very good efficiency on alternating circuits. The methods of insulation and of polyphase transmission have, moreover, been improved greatly within a year or two, and these have brought up the capabilities of the wire both for carrying more current and working at higher voltage than was before the case. In the present state of the art it would be safe for an electrical engineer

to contract to transmit any amount of power one hundred and fifty miles with a total loss on the line, due to fall of voltage, or "drop," and leakage, of not more than twenty-five per cent, and this without being too extravagant of copper. The voltage on such a line would be, however, much more than that referred to above—probably twenty-five thousand volts.

The distance from the Scotch side of the proposed line to London by air line is three hundred and sixty-five miles, and it is only reasonable to expect that the first decade of the twentieth century will see things so perfected as to admit of transmission over this distance of any desired amount of power. As it is, the great power-consuming counties of York and Lancashire, particularly the former, would to-day be accessible from the proposed power generators.

If we glance at the ultimate results of all this, we shall see them to be enormously far reaching. The limit to Britain's commercial greatness may be set, as things are now, at the giving out of her coal mines. These are not by any means inexhaustible, and the drain upon them is something awful. The amount used in generating power alone is annually in the scores of millions of tons, and this is over and above what is used for house-heating, cooking, etc.

Suppose now that there comes from the north an inexhaustible supply of electric energy—inexhaustible, that is, as regards the driving power it draws on, and limited in practice only by whether one is willing to pay the moderate price that its generation, transmission, transformation, etc., cost—we should have here a solution of the whole question of the future of the coal fields. The electrical power would be sufficiently cheap for general use, and in the great textile manufacturing districts the hum of the hundreds of thousands of cotton and woolen spindles would be supplemented by the lower note of the driving motors. Electric heating for culinary purposes is pre-eminently satisfactory, not only for its cheapness, since one can use the heat just where it is needed and avoid the waste of ninety-five per cent of the heat employed due to hot air going up the chimney of a cooking range and to radiation to an already overhot kitchen, but also on account of its entire cleanliness and reliability. If the price of coal should go up at all seriously, due to prolonged strikes, or to other causes, it would pay to use electricity for even house and store heating. In the vast iron-smelting industry it could be applied to at least greatly reduce the amount of fuel at present used. The only important place where it could not certainly pretty well displace coal would be in seagoing vessels, for they can not now, and probably never will be able to, navigate the ocean on the trolley principle, and it has to be said that it looks more like the job

of a century than of a decade to get the storage battery in shape for transatlantic working.

But the railways would all be run by it, and arc and incandescent lamps would shine on the country roads and in rural hamlets all along the distributing lines in the kingdom. The reign of electricity would have set in, for Great Britain at least, in a sense not realized at all as yet, though we speak of the present as the age of electricity; and the deadly smoke from London, Manchester, and Liverpool chimneys would cease, with its accompanying black and yellow fogs and consequent stagnation of business and various kinds of illness. St. Paul's could be cleaned up once for all and shine forth in its whiteness for generations, instead of becoming again the grimy and disreputable-looking object that the soot from London's bituminous coal has made it.

It is hardly to be expected that the great work referred to will actually be begun just yet, although it would be little more than an even thing between the cost of this fifteen-mile dam and Manchester's thirty-five-mile ship canal, but it is one of the great projects that the near future is likely to have in store, and all the results I have foreshadowed are logical outcomes of it. The length of time that the construction of such a work would require has been estimated at in the vicinity of three years, if properly pushed, and the cost would probably be something over one hundred million dollars.

Considering the thing from the broad standpoint of the change in the whole geography of the British Isles which would follow the construction of the isthmus, several most interesting and extremely important questions arise. As to whether these have been all carefully investigated by the projectors of the proposed enterprise I am not aware. In the first place, what would become of the water which at present finds a vent through the Irish Channel in case this channel were stopped? It would presumably go by the west coast of Ireland and a small part, perhaps, up round by the north and east of Scotland; and the question is, would this have a salutary effect upon the west Irish coast, and would it withdraw a part of the Gulf Stream's benign influence from England and the east coast of Ireland? The result of the work might possibly show it to have been unwise to tamper with the natural course of a main branch of that ocean current which is known to have such an excellent influence on the climate and temperature of the British Isles, which, as everybody knows, are as far north as Labrador. The possibility reminds one of the story of the Anglophobiac American who proposed cutting a canal through Yucatan, or some such locality, in order that the Gulf Stream might be nipped in the bud, so to speak, and never reach England

at all—thus turning, as he expected, that island into an abode of arctic snow and ice.

Another feature of the case is the fact that the daily tides would not be the same on the two sides of the dam. To the north one could look clear out to sea over the Atlantic Ocean; to the south is about three hundred miles of practically inland water before one gets out to the open ocean coast. The tides on the open coast are about the same height and come at about the same times south and north; and at present, at any given point in the Irish Sea, the height of the sea level at any time is determined by the resultant of the tides from the north and south respectively. The construction of a dam at the northern entrance would leave the whole Irish Sea subject only to the influence of the tides from the south, while on the north side of the dam the tide level would be the same as that of other points on the open coast. Since, now, it would take some time, probably several hours, for the effect of the southern tide to reach the south side of the dam, the tides on the two sides would be anything but synchronous. When the tide was at its height at the north side it would be, perhaps, half-way up on the south, and would be high on the south by the time a considerable recession had taken place on the north. This variation would have a most important bearing on the working of the power machinery at the dam, because, instead of the difference of level between the water on the two sides being constant, and giving therefore a constant pressure, it would vary so as to be at times greater and at times less than would be the case if the effect alluded to did not take place. In order, therefore, to supply an equable driving head to the dynamos, the turbine wheels would have to be powerful enough to work up to the required capacity on the minimum difference of level. Since the power made available by the dam would be remarkable for the vast volume of water to be drawn on, rather than for great difference of level, the interference of the tides in at times reducing this difference perhaps considerably would be a matter of grave inconvenience in the way of the successful operating of the power generators.

The system of school education, though judiciously criticised, is not regarded in the paper of Prof. Glynn, of Liverpool, on excessive mental work and some of its consequences, as being in a marked degree accountable for nervous overstrain in childhood. The tendency to this effect is considered to be in a great measure counteracted by the attention given to physical education and by the mental elasticity natural to youth. More serious are the consequences entailed by close and anxious application to duty of teachers and older students. As concerns the adult population, the injurious influence of overstrain is most active in towns, where the tension in the struggle for existence is greater and is associated with a desire too easily gratified.

RAIN-MAKING.*

By FERNANDO SANFORD,
PROFESSOR OF PHYSICS, LELAND STANFORD JUNIOR UNIVERSITY.

I SHALL ask your attention this evening to the scientific principles which are involved in the condensation of atmospheric vapor, and to some of the attempts which have been made to produce this condensation by artificial means.

Since the change from atmospheric vapor to water involves a change of the physical state of the same substance from a gas to a liquid, it is important that we understand clearly the difference between these two physical states.

Both liquids and gases are undoubtedly made of very small particles called molecules. In a gas these molecules are not held together by any force, but each molecule is a perfectly independent body, free to move in any direction without reference to any other molecule, except as its motion may be interfered with by colliding with another. Under all known conditions these gaseous molecules are actually in rapid motion, each one moving at its own rate and in its own path, unaffected by any known force except gravitation. Each molecule will, accordingly, move in a straight line until it collides with another molecule. When two molecules collide, their direction of motion will be changed according to the angle of collision, but on account of their high elasticity they rebound with the same force with which they collide, and the sum of their motions will be practically the same as before. Hence, no number of collisions between the molecules themselves will ever bring them to rest.

If confined within solid walls, they strike against these walls and rebound from them just as they do from each other. In doing so each molecule exerts a pressure upon the wall during its time of contact, and the sum of these pressures is the whole pressure of the gas upon the walls of its containing vessel.

These walls are likewise composed of similar molecules, but held together by some unknown force, and it is the surface layer of these molecules which must bear the shock of the molecular bombardment of the gas. Accordingly, the molecules of the solid walls, while not free to be driven about from one place to another, like the gaseous molecules, are nevertheless set in vibration; and since they can not lie as close together while in vibration as they could at rest, the solid mass of the walls is made to expand. By measuring the amount of this expansion we can de-

* A lecture given before the students of the Leland Stanford Junior University, March 6, 1894.

termine the energy of the molecular bombardment. By letting the vibrating molecules of the solid or the gas come in contact with the parts of our skin to which certain special sense nerves are distributed, we feel the sensation of heat, and we are accustomed to say that the expansion of the solid or the gas is due to heat. The total measure of the energy which any mass of matter has on account of the motion of its molecules is determined by the amount of heat—i.e., molecular motion—which it must give to other bodies before its molecules can come to rest. The higher the temperature of the mass—the more heat or the more molecular motion it has.

The atmosphere is, in general, made up of two different kinds of molecules. These molecules are, of course, very small—so small that no possible magnifying power can ever bring them into view. Their size is, in fact, so small as compared with the length of a light-wave that no image of one could be produced by reflected light. Still, there are several independent methods of calculating their approximate size, and, since these different methods lead to fairly accordant results, we may assume that their approximate size is known. According to Lord Kelvin's computation, if a drop of water were magnified to the size of the earth its molecules would become larger than shot and smaller than cricket balls, perhaps about the size of marbles. They are so close together in the air that the number in a cubic inch is represented by the number ten raised to the twenty-third power. Being so close together, and being at the same time in rapid motion, they must have frequent collisions, and, according to Maxwell's calculation, a molecule of air at ordinary temperatures would have seven or eight hundred thousand millions of collisions in a second of time. While these figures, both for size and number, can convey no definite meaning to us, they may aid us in picturing to ourselves the tremendous agitation which is constantly going on within our atmosphere or within the mass of any other gas.

Within the body of a liquid the conditions are similar, except that here the molecules are so close together that they can not be said to have any free path at all, and are, accordingly, in a state of perpetual collision. They are not, as in a solid, held to any definite position with reference to the surrounding molecules, but are hindered by a force called cohesion or capillarity from escaping from the liquid altogether. What the nature of this force is is not known, but it is evidently a pressure of some kind exerted upon the molecules tending to push them closer together.

Notwithstanding this force, the molecules of the liquid are in rapid vibration, and at the free surface of the liquid they are being continually bumped off by the molecules below them. When

this happens they become free gaseous molecules, and move off in straight lines under the impulse of the force which set them free until they come into collision with other molecules.

At the surface of separation between water and air the conditions are accordingly as follows: The surface layer of water molecules is held down by the force called cohesion, but the individual molecules of this layer are being continually bumped off by the vibrations of the molecules below them. Some of these free molecules are undoubtedly driven back by the bombardment of the air molecules above them, so that they escape much more slowly into the air than they do into a vacuum, but those which once escape into the air are knocked about by the air molecules and by each other until they are pretty evenly distributed throughout the air. After a time they become so numerous in the space above the water that, in their irregular excursions between their collisions with other molecules, they begin to strike the surface of the water, and then, under favorable conditions, they penetrate into the liquid and are held fast. This process continues until finally as many molecules enter the water as escape from its surface, and then, while a constant exchange is taking place between the liquid and gaseous molecules, the average number in the space above the liquid remains constant. This space is then said to be saturated with vapor molecules. The number of molecules required to saturate this space is the same whether the space already contains air molecules or not, but, on account of the number of water molecules which are beaten back by the air molecules, it takes much longer for the space to become saturated when it is already filled with air than it does when there are no other molecules in it. The air molecules, however, hinder the vapor molecules from striking the surface of the water as often as they prevent them from leaving the surface, so they do not influence the total number required to produce saturation.

When the point of saturation has been reached, an increase of temperature—i. e., an increase of the molecular vibration of the water—causes the molecules to be driven off faster than before. It also causes the gaseous molecules to strike the surface of the water oftener than before. But an increase of temperature means a corresponding increase of vibration of all the molecules; and, since there are very many more liquid than gaseous molecules in the same volume, the total increase of molecular vibration corresponding to a given rise of temperature will be much greater for the liquid than for the gas, and a correspondingly greater number of molecules will be thrown off at the surface of the liquid than will be returned to it. Accordingly, the higher the temperature, the more molecules are required to saturate the space above the water. In fact, the amount of water vapor required to pro-

duce saturation of the atmosphere under the conditions above mentioned is more than twice as great at 80° F. as at 50° F.

On the other hand, lowering the temperature of the liquid and vapor by a like amount lessens the number of molecules given off from the liquid surface more rapidly than it lessens the number striking upon the surface. Accordingly, we say that raising the temperature increases evaporation; lowering the temperature increases condensation.

Now, it happens that this same force of cohesion may hold water molecules upon the surface of most solid bodies as strongly as upon the surface of water itself, and in many cases even more strongly. Accordingly, if a solid body of this kind be placed in the atmosphere, the same exchange of water molecules will take place between its surface and the air as between a water surface and the air. In fact, as soon as a layer of water molecules is formed over its surface, it becomes a water surface. Accordingly, if a solid particle be placed in an atmosphere saturated with water vapor and the temperature be lowered, the water molecules will accumulate upon its surface faster than they are driven off, and we say that a precipitation of dew is taking place upon it. The air is accordingly said to reach its dew point when it reaches its point of saturation.

There are other substances which hold fast in a different way the water molecules which strike upon their surface. These substances form either chemical compounds or solutions with water, and in this way remove the water molecules from the places where they strike to the interior of the compound or the solution. Sulphuric acid is a good example of this class of substances. If a vessel of sulphuric acid be placed in a receiver filled with water vapor, the acid holds fast all the water molecules which strike its surface, and sends off no other water molecules to replace them. Since all the water molecules in the receiver will in time come in contact with the acid surface, they will ultimately all be held in a liquid form by the acid. Accordingly, a receiver of moist air can be changed to dry air by allowing it to stand for a sufficient length of time over sulphuric acid.

There are very many other substances which, like sulphuric acid, have the property of condensing the water molecules from a space which is not saturated with them. Such substances are said to be deliquescent, or to gather moisture from the air. Common salt and caustic potash are good examples of deliquescent substances.

There is still another method of producing condensation. If an inclosed space contain water vapor enough to bring it to the point of saturation, and if the volume of the space be decreased without changing the temperature, more molecules will strike

upon a given surface of the containing walls than when the volume of the gas was greater. Since the temperature remains the same, the same number of molecules will be driven off from a given surface of these walls as before. There will, accordingly, be a condensation upon the walls, which will continue until enough gaseous molecules have been removed to make the exchange again even.

These are the three known methods of changing water vapor to the liquid form—viz., by lowering the temperature of the vapor and the other bodies in contact with it until the point of saturation has been passed, by compressing the vapor until there are enough molecules in unit volume to produce saturation, and by allowing the vapor molecules to strike upon some surface which will immediately take them into solution or into chemical combination. I know of no other method by which water vapor, or any other vapor, can be changed into the liquid form.

The conditions necessary for the precipitation of the aqueous vapor from the atmosphere are, then, as follows:

(1) The air must contain enough molecules of water vapor to more than saturate it, and must contain at the same time either solid or liquid bodies upon which these vapor molecules may be held fast by cohesion; or (2) the air which does not contain enough water vapor to saturate it may come in contact with solid or liquid substances, which combine with or dissolve the water molecules which strike upon them.

This latter condition can manifestly play no important part in atmospheric precipitation. The only condition under which such substances could cause condensation above the earth's surface would necessitate their distribution throughout the atmosphere, and if they were so distributed they would constantly absorb the atmospheric vapor until, loaded down with it, they would sink to the earth, and there would be a condition of perpetual rainfall.

For the general precipitation of atmospheric vapor we must accordingly depend upon the condensation due to cohesion. Of this form of condensation, dew is the simplest illustration. During the day the earth and the solid bodies upon its surface are raised by the sun's radiation to a temperature higher than that of the surrounding air. So long as this is the case the atmospheric vapor will not condense upon them, even if the air be cooled to the point of saturation. In the night the same substances which absorbed the sun's heat fastest now radiate it fastest and soon become colder than the surrounding air. As soon as they are cooled to the temperature of saturation of the surrounding air the vapor molecules begin to condense upon their surface.

Now, the condensation of water vapor in the air above the sur-

face of the earth is dependent upon exactly the same conditions as the formation of dew. It used to be thought that, as soon as the air was cooled to or below the dew point, the molecules of water vapor in the air would come together and form drops of water. In 1880 Mr. John Aitken, of Scotland, began a long and very thorough series of experiments upon the condensation of water vapor from the air, and the same line of experimentation has been carried still further by Robert von Helmholtz and by Richarz in Germany. These experiments have all shown that vapor condensation within the body of the air only takes place upon the surface of dust particles which are floating in the air. Indeed, Robert von Helmholtz found that when the air was carefully freed from dust particles it could be cooled until it contained ten times the amount of vapor necessary to saturate it without any condensation taking place within the body of the air. Aitken thought that he had found one exception to this, and that in the case of a sudden shock upon the walls of the containing vessel, when the air within was oversaturated, precipitation would take place; but Robert von Helmholtz found that this apparent exception was due to the dust particles given off by the walls of the vessel at the time of the shock. Since this fact has been experimentally established, Lord Kelvin has shown mathematically that, from the known laws of surface tension in water, it would be impossible for a globe of water consisting of only a small number of molecules to hold together at all. The same calculation has been made by Robert von Helmholtz by means of a formula developed by his illustrious father. According to these calculations, the smallest sphere of water which could hold together at 0° C. would be ·00015 millimetre or ·000006 inch in diameter. Since this is 7,500 times the diameter of a water molecule as computed by Lord Kelvin, the smallest drop of water which could be held together by cohesion at this temperature would contain not less than four million millions of water molecules. At 40° the smallest possible water sphere would have a diameter about twice as great, and would accordingly contain eight times as many molecules.

Aitken found that dust particles of microscopic size were sufficient for the nuclei of condensation, and R. von Helmholtz showed that condensation could take place upon particles so small that it took four days for them all to settle through still air to the lower side of a horizontal glass tube about one inch in diameter.

Aitken counted the number of these dust particles in different samples of air by first diluting the air with two hundred times its volume of air which had had its dust particles removed by being drawn through water, and then saturating the air with water and cooling far below its dew point, and counting the number of

water drops falling upon a given area until all the dust particles were carried down. He found the number of dust particles to vary from 34,000 per cubic inch in pure air taken from the top of Ben Nevis to 88,346,000 per cubic inch in air taken from a room near the ceiling, and nearly 500,000,000 per cubic inch in the flame of a Bunsen burner.

The number of these dust particles in the air determines the character of the precipitation. If the dust particles are very numerous, each one becomes a nucleus for the condensation of water vapor, but only a small quantity of water will be condensed upon each one; hence the formation of the fine drops which constitute fog. If the number is smaller, as it is likely to be at a greater distance above the earth, each nucleus may receive a larger quantity of water, and a cloud may be formed. If they are few, or if the total amount of condensation is great, the drops which are formed become heavy enough to fall to the ground, and rain is produced. If the nuclei are very few, rain may fall from an almost cloudless sky.

It is well known that as we ascend above the earth the temperature falls about one degree Fahrenheit for three hundred feet; consequently, while the air at the surface of the earth may be far above the dew point, the air at a few thousand feet above the earth may be cooled below the dew point. The height of the clouds always indicates the distance above the earth at which the air is cold enough for condensation to begin. The clouds, being made up of these little dust particles surrounded by water, are heavier than the air, and are slowly settling toward the earth, but as fast as the little drops settle into the warmer air, the rate of evaporation from their surface is increased, and before they have settled far the water has been evaporated off. Hence, at a given time, over an area of uniform temperature, the lower surfaces of the clouds are all at nearly the same distance above the earth.

How, then, shall rain be produced in the great unbounded atmosphere? There are but two ways. Either the total quantity of vapor in the atmosphere must be increased, or the temperature of the air must be diminished. It is probably safe to assume that there are, under all ordinary circumstances, a sufficient number of dust particles in the air to form the nuclei for condensation, so that no artificial provision need be made for these.

So far as I am aware, no enterprising rain-maker has yet proposed a method of increasing the total moisture of the air to any appreciable extent, though some of them have attempted this on the small scale, probably in the vain hope that if they touched the button Nature would do the rest. This, by the way, has been the one claim upon which all these pretenders have based their arguments. They have steadfastly and with unanimity asserted

that if a little condensation could be started in one place it would at once spread out in all directions, like the benign influence of the little homœopathic pill. How a rainfall started in this way is ever to stop as long as any aqueous vapor remains in the air, they have not condescended to tell us. This question has not, so far as I know, ever been raised by the results of their incantations.

As a matter of fact, every drop of water taken from the air decreases the number of vapor molecules remaining, and, consequently, lowers the temperature of the dew point. Likewise, every free molecule which is brought to rest by striking against a solid body, gives up its energy of motion to that body and increases the total energy of its molecular vibration, so that a body upon which water molecules are condensing is having its temperature continually raised, and it must be continually giving off heat to surrounding bodies, or it will soon be warmed above the temperature of condensation. In the case of the dust particles of the atmosphere, they must give off this acquired heat to the molecules of the air which come in contact with them; hence the condensation of moisture from the air raises the temperature of the air. There are, accordingly, two reasons why heat must be continually taken from the air in order to keep up condensation. The temperature of the dew point is being continually lowered by the loss of vapor molecules, and the temperature of the air is being continually raised by the amount of heat which these molecules lose when their motion is stopped.

In the formation of rain by natural causes this continuous decrease of temperature is provided by ascending currents of air which carry the water molecules upward into continually cooler and cooler regions. These ascending currents of air may be caused by mountain ranges which deflect upward the winds that blow against them, by the expansion of the air over a heated area of the earth's surface, and possibly by other agencies not yet understood. In the case of our California storms, these ascending currents are usually persistent for several days, frequently moving across the whole continent. They are marked upon our weather maps as areas of low barometric pressure. Whenever there is an area over which the barometric pressure is less than the normal, it is an indication of an ascending current of air, and wherever there is an ascending current of air there is a probability of rainfall, though if the air be very dry it may not be carried to a sufficient height to be cooled below its dew point.

On the other hand, wherever there is an area of increased barometric pressure, or of high barometer, it is an indication that there is a descending current of air over that area; and since air which is settling toward the earth is continually having its temperature

raised, no precipitation of moisture will occur over an area of high barometer.

The simultaneous weather observations conducted by the Government enable us to locate these regions of ascending and descending currents, and long observation has enabled us to predict their probable path across the continent, and it is upon these data that the weather officers base their predictions of future weather. Since these areas regularly travel from west to east, we in California receive much shorter notice of their coming than do the people farther east, and the weather predictions issued from our local bureau are proportionally more liable to error than are those issued from stations beyond the mountains.

And now as to the possibility of producing rain by artificial means. It is never safe to say what things are possible and what things are impossible to man. What the future may bring forth no one can tell. At the present time, however, there is no evidence to show that even the smallest local shower has been produced artificially. Further than that it is safe to say that no method of producing artificial rain has yet been publicly proposed which suggests to one familiar with the scientific principles involved even a possibility of success. That such attempts have received the official recognition and the financial support of Congress is only another evidence of the gross ignorance of scientific principles which is prevalent among our so-called educated men. That some of the men who advocate these wild schemes are honest in their motives can not be questioned, but that all the professional rain-makers are conscienceless fakirs is scarcely more questionable. That many of them are able to submit testimony as to the efficacy of their system is equally true of every patent-medicine fraud and electric-healing quack who has ever swindled an ignorant public. As an illustration of the value of testimony of this kind let me give you a local example.

I will read from the San Francisco Examiner of February 2, 1894:

HE PRODUCES RAIN AT WILL.

HIGHLY SUCCESSFUL EXPERIMENTS OF THE VISALIA RAIN-MAKER.

HEAVY SHOWERS AT PIXLEY.

HE SELECTS THE DRIEST SECTION OF FRESNO COUNTY, WHERE RAIN SELDOM FALLS, AND BY THE USE OF CHEMICALS CAUSES LOCAL DOWNPOURS ON TWO SUCCESSIVE DAYS.—MANY OTHER TESTS MADE.

VISALIA, February 1st.—A week ago Wednesday Frank Baker, of Visalia, an amateur rain-maker, went to Pixley for the purpose of producing rain. Before he left he informed the Examiner correspondent that he intended to produce rain within seven days, and he kept his word. On Tuesday and Wednesday a local rainstorm occurred in the vicinity of Pixley amounting to 0·35 to 0·45 of an inch.

Mr. Baker returned to this city this morning in jubilant spirits. He is now satisfied beyond a doubt that he can produce rain by means of his appliance. He proposes to visit Pixley every two weeks, and is sanguine that he will be successful in his experiments.

During the months of April and May he proposes to put forth his best efforts in order to thoroughly drench the soil. The residents of Pixley are well pleased with Baker's experiments, and they propose to assist him in conducting his future operations.

THEY VOUCH FOR HIS EFFICIENCY.

He brought back with him the following letter:

"This is to certify that it rained 0·35 to 0·45 of an inch at Pixley on the 30th and 31st of January. We gentlemen here vouch for the truth of the same; that it is a local rain of fifteen to twenty miles in extent, and that it was brought about by the Baker process.

"J. J. KELLY,	L. E. SMITH,
"CHARLES S. PECK,	J. T. AUSTIN,
"W. M. JACKIN,	JOHN W. HARPER."

Now, it is not my purpose to impugn the veracity of the gentlemen whose names are signed to this certificate. I know none of the gentlemen. I do not question the only point in the statement to which the gentlemen could possibly subscribe of their own knowledge. You will observe that the certificate includes three separate statements: (1) That it rained in Pixley on the 30th and 31st of January; (2) that it was a local rain of fifteen to twenty miles in extent; (3) that it was brought about by the Baker process. Manifestly, the only one of these statements to which the gentlemen could have subscribed of their own knowledge is the first.

Fortunately for the settlement of questions of this character, we have the use of data collected by the Weather Bureau. When I read the above article I at once wrote to Mr. Pague for the maps issued by the Weather Bureau for January 28th to 31st inclusive. He kindly forwarded them to me, and the following data were compiled by me from them:

On the map of Sunday, January 28th, 5 P. M., an area of low barometer is shown with its center west of Vancouver. The weather was reported cloudy and rainy north of the Oregon line. The weather forecast was "Rain in northern California." Twelve hours later, Monday, January 29th, at 5 A. M., the storm was central over northwestern Washington. I quote verbatim from the predictions printed upon the map: "The conditions this morning are favorable for rain over California from the Tehachapi Mountains northward by Tuesday morning, and possibly will extend southward Tuesday afternoon or night."

At 5 P. M. of the same day the map shows a storm area extending from British Columbia to southeastern California, with its

center near Keeler, about ninety miles east of Pixley. Here the storm center remained for thirty-six hours, while the storm was gradually breaking up over its northern part, as shown by the three following maps, and not until the map of Wednesday morning is there an indication of an eastward movement of the storm, while as late as 5 P. M. of Wednesday, January 31st, rain was reported at Keeler. During Monday and Tuesday light rains were reported over nearly all parts of the State, and on Tuesday it rained at Pixley.

From these data we see that the local rainfall produced by the Baker process at Pixley was part of a storm which extended over a large part of British Columbia, over Washington, Oregon, California, Utah, Nevada, and Arizona, and which had its center for thirty-six hours within ninety miles of Pixley, and that the weather forecasts sent out from San Francisco on Monday morning at five o'clock predicted rain for the region about Pixley for Tuesday afternoon or night. As a matter of fact, it rained at Pixley on Tuesday night, as had been predicted by Mr. Pague thirty-six hours before.

I have referred to this special case, not because it differs in any essential particular from other well-authenticated cases, but because one typical example which any one can verify is worth a great amount of generalizing, and because this particular instance has been so prominently mentioned by the press of the State.

And now I wish to say a few words about the methods of some of the best known of the professional "rain-makers." For most of the following data I am indebted to a paper read by Prof. Alexander Macfarlane, of the University of Texas, before the Texas Academy of Science.

Powers.—In 1870 Mr. Edward Powers, of Delavan, Wis., published a collection of statistics in a volume entitled War and the Weather. By means of these statistics he seeks to establish the remarkable fact that battles are followed by rain. He does not prove that battles are necessarily accompanied by rain, or that a day of battle is followed more quickly by rain than a day of no battle. Having, however, apparently convinced himself of the value of his argument, he at once adopted the universal American expedient of proving his claim, and petitioned Congress for an appropriation to make a suitable test. Two hundred siege guns which lie idle at the Rock Island Arsenal were to be taken to a suitable locality in the West, and one hundred rounds to be fired from them in each of two tests. The estimated cost of the experiment was to be one hundred and sixty-one thousand dollars. He does not tell us how the molecular vibration caused by the sound and heat of the firing is to lessen the molecular vibration of the air and cause the vapor molecules to come to rest.

Probably the distinction between a scientist and a crank could not be shown more clearly than in a comparison of the methods of Aitken and Von Helmholtz with the methods of Powers. The former spent years working in private and at their own expense to find if possible some explanation of the mystery of condensation. The other wished an appropriation of one hundred and sixty thousand dollars from the Government in order to test his visionary hypothesis.

RUGGLES.—In 1880 Daniel Ruggles, of Fredericksburg, Va., patented a process for producing rain. The invention, as described by Mr. Ruggles, consists of "a balloon carrying torpedoes and cartridges charged with such explosives as nitroglycerin, dynamite, gun cotton, gunpowder, or fulminates, and connecting the balloon with an electrical apparatus for exploding the cartridges."

This is another scheme for lowering the temperature of the air by heating it.

DYRENFORTH.—It is probable that the name of Mr. Dyrenforth is better known in connection with attempts at artificial rain-making than that of any other man. As a result of the agitation of Mr. Powers, Congress voted two thousand dollars to make a preliminary test, and the inquiry fell to the scientists connected with the Department of Agriculture. They reported that there was no foundation for the opinion that days of battle were followed by rain any more than days of no battle. It was then that Mr. Dyrenforth came forward with Ruggles's plans and offered to make some tests. Through the influence of Senator Farwell, an additional appropriation of seven thousand dollars was placed at his disposal for a series of practical tests, which were made at Midland, Texas, in August, 1891. A further Government appropriation was expended in tests at San Antonio, Texas, in November, 1892.

Mr. Dyrenforth's plan seems to have been to imitate as nearly as possible the conditions of a battle. His explosives were ranged in a line facing the advancing clouds. Shells were fired into the air at frequent intervals. Dr. Macfarlane states that the "general" and his lieutenant even wore cavalry boots.

In addition to these warlike demonstrations, cheap balloons containing hydrogen and oxygen mixed in the proper proportions for forming water were sent up, and the gases were exploded by means of a time fuse attached to the balloon.

At the time of making the San Antonio tests, November 25, 1892, the record of the weather office in San Antonio at 8 P. M. gave the temperature of the air at 72° F. and the temperature of the dew point as 61° F. Dr. Macfarlane makes the following calculations upon a cubic mile of the air under the above con-

ditions: To cool down the cubic mile of air to the dew point would require the abstraction of as much heat as would raise eighty-eight thousand tons of water from the freezing to the boiling point. To cool it eleven degrees more would require the abstraction of the same quantity of heat again. This would cause the precipitation of twenty thousand tons of water, which, spread over a square mile, would give 1·4 pound per square foot or 0·27 of an inch of rain. The amount of heat which the twenty thousand tons of water vapor would give off to the particles upon which it would condense would raise a hundred thousand tons of water from the freezing to the boiling point, and this would also have to be taken from the air in order to allow the condensation to continue. According to this computation, enough heat would have to be extracted from the air to raise two hundred and seventy-six thousand tons of water from the freezing to the boiling point in order to produce a rainfall of about a quarter of an inch over an area of a square mile. This two hundred and seventy-six thousand tons of water would cover the same area to a depth of more than six inches. Accordingly, in order to produce a rainfall of a quarter of an inch under the conditions mentioned, enough heat would have to be taken from the air to heat a body of water covering the whole area to a depth of ninety feet through one degree Fahrenheit.

To accomplish this purpose Mr. Dyrenforth proceeded to raise the temperature of the air still higher by means of heat-producing explosives.

Under these conditions eight balloons, a hundred and fifty shells, and four thousand pounds of rosellite were fired off. No rain appeared. One balloon exploded within a black rain cloud, but failed to produce any precipitation. On the following Wednesday, with a clear sky, ten balloons, a hundred and seventy-five shells, and five thousand pounds of rosellite were exploded, and the sky remained clear. On the following night the remaining stock of explosives were fired off, regardless of consequences, to get rid of them.

At the time of this national *fiasco*, another patented plan of rain-making was published, and it was reported that Senator Farwell liked it even better than the concussion plan. It proposes to send up liquefied carbonic acid and to set it free in the portion of air from which it is desired to precipitate the rain. The carbonic acid in vaporizing and expanding must take heat from the surrounding air sufficient to set its molecules vibrating in the gaseous form. Unquestionably we have here the proper kind of an agent for producing rain. The only question to be considered is one of finance. Prof. Macfarlane estimates that one pound of carbonic acid in taking the gaseous form at 72° F. would take up

enough heat to change sixty-eight pounds of water by one degree Centigrade. To cool the cubic mile of air formerly considered sufficiently to make a rainfall of a quarter of an inch would accordingly take four hundred and six million pounds of carbonic acid. This could probably be purchased in quantities of this magnitude at one dollar a pound, making the expense of a rainfall of a quarter of an inch, not counting anything but the carbonic acid, about six hundred thousand dollars per acre. This would make artificial climate even more expensive than the genuine California article.

I have now endeavored to give you in as brief a space as possible a simple statement of the problem of rain-making as it appears to one with an elementary knowledge of physics, and to give a brief statement of some of the methods of the men who, without any scientific knowledge, have intentionally or unintentionally imposed upon the public. The examples which I have quoted are only the prominent ones. There are many impostors whose names are but little known who are proposing to furnish rain to large sections of country for a suitable financial consideration. And it is only surprising that the number is not larger. The business offers special inducements to men who are accustomed to make a living by swindling their fellow-men. No capital and no business training is required. The only thing necessary is to contract to furnish rain to as many different sections of country as possible. Then, if it rains over any of these areas, collect the pay. If it does not rain, the experiment has cost nothing. The system has all the advantages of the traditional gun loaded to kill if it is a deer, but to miss if it is a calf.

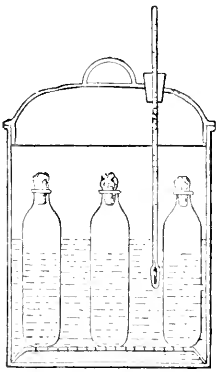
MILK FOR BABES.

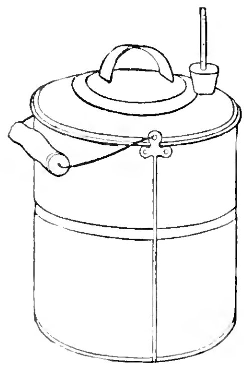
By Mrs. LOUISE E. HOGAN.

IN the natural advance made in the study of the subject of infant foods—methods of preparation, administration, etc.—the process of sterilization of milk, as ordinarily and formerly understood, is now replaced by "Pasteurization," which is, practically speaking, the low-temperature process of the earlier method, and specialists who comprehended the serious changes produced in milk by high and prolonged temperature advised from the first the lower method.

It is easy enough, by prolonged and repeated application of a high temperature, to keep milk apparently unchanged, but the point aimed at all along has been to devise a way by which it might be made sterile with the least possible interference with

its nutritive qualities. Investigation has demonstrated that milk subjected to lengthy boiling under pressure is in many ways unsuited to the digestion of an infant. Chemical analyses have proved what experience has shown to be the case—namely, that milk sterilized by the higher and prolonged temperature is not fit for administration to an infant. Dr. Henry Chapin, of New York, has been making a study of infant feeding and of children in the Post-graduate Hospital of that city, to which he is attached, and he says, in an article recently published in the New York Medical Journal, that partial sterilization or Pasteurization, to the point of killing the germs only, is necessary and desirable, as a high and continuous temperature produces unfavorable changes in the milk; the fat collects in masses, the albuminoids are changed, the casein is altered, and the digestive action on the casein of sterilized milk is incomplete. Simply





sufficient heat must be applied to the milk to keep it sweet until the next supply can be procured. Herein lay one of the most frequent sources of trouble in the earlier days of sterilization, caused by lack of exact knowledge in this direction; and in addition to this, when sterilized milk was first introduced, many mothers reasoned that, being sterile, it was a perfect food, and consequently used it without any further preparation, with the natural result of indigestion and all its resultant ailments. It is quite true that milk to be a perfect food must first be sterile, but it must also be assimilable; and to reach this point great care must be given as well to its preparation and administration. Notwithstanding the care exercised by boards of health, it is impossible at any time to be sure of the purity of the milk supply; hence the need is urgent that it be made safe by Pasteurization, which is, in reality, simply subjecting the milk to the lower temperature of 150° to 160° F., instead of 212° F., as was formerly done, and is called thus in deference to Pasteur, who long ago found that the ordinary germs of fermentation and bacteria

would be destroyed by this temperature, and recommended such a process for their destruction and for the preservation of foods. Thirty years ago Liebig said that by scalding milk once a day it could be kept indefinitely, and many a housewife, before and since, has put the same fact into practice. The process is new only in name—the discovery lies principally in its application—experiment having shown that the application of 150° F. for thirty minutes will destroy the *Bacillus tuberculosis* with certainty, and many germs that are likely to be found in reasonably pure milk, which, with ordinary precaution, will remain sweet for several days.

There is a good deal in a name, and it is to be hoped that "Pasteurized" milk will receive as cordial a welcome as was given to "sterilized" milk.

Generally, new ideas are received with some conservatism and are subjected to tests in expert hands before being adopted by the public; but the need was great, and it is seldom indeed that anything has had the benefit of so wide a trial and so immediate an acceptance as this idea of sterilization of milk. Benevolent persons opened dispensaries to give it to the poor, who, jumping to the conclusion that it was "exactly like mothers' milk" and had wondrously valuable qualities, failed frequently to see the true purpose of the work. Few stopped to inquire what sterilized milk really was, and directions given for its use were rarely followed.

The fact that milk, when subjected sufficiently to a high temperature, can be kept unchanged for an indefinite length of time, while of interest from a scientific standpoint, is of no practical interest to consumers, except upon long journeys, as it has been conclusively shown that for ordinary usage Pasteurization should be done daily. It is generally conceded that pure milk will save much infant mortality. The fact that thousands of children—especially infants—die every year from want of care in the preparation of their food is underestimated by many. At one of the meetings of the Philadelphia Board of Health, Dr. Shakespeare said, in his report, that milk of poor and unwholesome quality is originally and directly responsible for thousands of deaths annually in that city alone, not to speak of the sickness from this origin which is not fatal. To this category, he declares, certainly belong most deaths from cholera infantum, infantile tuberculosis, many of the deaths from acute diarrhœa, from typhoid fever, and some of the deaths from diphtheria and scarlet fever.

Dr. Chapin says that of six hundred infants whose cases were studied, nearly all the troubles were acquired and not hereditary. "While a tendency to constitutional disease may be inherited, it is the bad surroundings and faulty conditions of life that powerfully predispose to illness"—poverty and ignorance being the

chief sources of difficulty. He says the waste of child life in densely populated centers, especially in New York, is enormous. Last year the bodies of three thousand and forty-two children under five years of age were received at the morgue and nearly all were buried in Potter's Field, killed by poverty and ignorance, want of proper diet and care. In France, out of two hundred and fifty thousand infants dying annually, M. Rouchard, President of the Society for the Protection of Children, says one hundred thousand might be saved by careful nursing. This knowledge caused the passage of the bill forbidding the use of solid food for infants under one year of age, unless advised by a physician.

In the effort to guard against the tuberculosis germ our own Government is taking action, and the United States Department of Agriculture, in connection with work upon the forthcoming report upon tuberculosis, has issued a circular giving simple directions for the sterilization of milk. Dr. Salmon, in his report, comments upon the danger of contagion, and says the sterilization of milk can be satisfactorily accomplished by a very simple apparatus, which he describes at length. Any suitable utensil—whether a bottle plugged with cotton or a Soxhlet stopper, a fruit jar loosely covered, or whatever vessel may be used—is to be placed inside of a larger one of metal containing water, the requirements being that the interior vessel shall be raised above the bottom of the other, and that the water shall reach nearly or quite as high as the milk. The apparatus is then heated until the water reaches 155° F., when it is removed from the heat and kept tightly covered for half an hour. The cooling after this should be rapid, and the bottles kept in a low temperature. A hole may be punched in the cover of the pail, a cork inserted, and a chemical thermometer put through the cork, so that the bulb dips into the water, or a dairy thermometer may be used by removing the lid from time to time.

An ordinary double boiler will be found to meet all the requirements, using the dairy thermometer. If preferred, the Arnold steamer or the Freeman Pasteurizer will be found convenient. Dr. Chapin says that fifteen minutes' heating will be found sufficient, as a rule.

The problem seems to be, in infant dietetics, to approximate such milk to the composition of human milk. That this can be done has been demonstrated by expert analyses, results showing that the value of this care is not overestimated by those who thoroughly comprehend its purpose. The casein of the milk, being the objectionable feature for infant diet, must be treated in such a manner as to make it digestible, supplying at the same time the constituents required as a consequence of this treatment, by the addition of sugar and fat.

Clinical results point to barley water as the best diluent, as it produces the finest curd. As a result of Dr. Chapin's study and experiments made by Dr. Arnold Eiloart, a receipt has been devised by which a mixture of barley or wheat flour is treated with maltine, the effect of malt upon milk being to favor its digestion and assimilation. Dr. Judson C. Smith, who is a district visitor for the hospital mentioned, says he has used the extract of malt to peptonize milk for about a year, both for infants and adults, with very satisfactory results. His method has the advantage of simplicity. One tablespoonful of malt is added to a pint of milk, which is heated from twenty to thirty minutes and then brought to the boiling point, which practically Pasteurizes the milk. It is to be diluted for administration according to the age of the infant. Top milk should be used with the proportion of cream sufficient to give at least four per cent after dilution; thus, twelve per cent of cream would be required to allow for two parts of water to one of milk, which is the dilution advised by Dr. L. Emmett Holt in order to reduce the proteids to their normal proportion. By careful experiment he has found that one quart of ordinary cow's milk, allowed to stand for six hours in a common fruit or milk jar, will give about five ounces of top milk of this strength.

The underlying truth of all the past and present agitation concerning the purity of the milk supply and the artificial feeding of infants is that both have been sadly neglected for many years, with the pitiful result of a vast amount of suffering and many useless deaths of children from one to five years of age, especially during the hot summer months, when it is so difficult not only to secure but also to protect the milk upon which these little ones depend. Comparatively few people stop to consider how quickly dangerous changes take place in this important article of food and how readily it becomes contaminated by absorption of various volatile substances. This is particularly true of those who have the immediate charge of milk. It is appalling to any one understanding the subject and its bearings to see the carelessness that is frequently displayed by the milkmen, maids, and nurses, all of whom play so important a part in infant dietetics. Is it any wonder that philanthropists, scientists, and physicians have combined in solicitous effort to wake up mothers to the crying need for a pure supply of milk and for its proper administration to save helpless and suffering infants? The subject is of infinite importance, and should be kept constantly to the front. The truths concerning it should be iterated and reiterated until satisfactory evidence has been given that persistence in a cause like this has been of some avail in changing existing conditions that are a reproach to our people and a menace to our health as a nation.

NATURE AS DRAMA AND ENGINERY.

By GEORGE ILES.

PROF. EDWARD B. POULTON, of Oxford, in closing his course of lectures at Columbia College, last February, described the cordial reception extended him on his arrival in New York. Taking a stroll through Central Park, he had walked but a few paces when a gray squirrel ran from a tree to his feet in the friendliest way possible. "The perfect trustfulness of the little creature," said Prof. Poulton, "told me at once the most important fact of its life—that here in the midst of a teeming population it was certain of kind treatment. I inferred that a community kind to animals must be interested in them, must be fond of studying them in the very best place, their field of life." Nor was the naturalist disappointed; he found his New York audiences enthusiastic, and his lecture room, crowded to the door, contained less than half those who sought admission. Just as his observation of the squirrel in the act of soliciting luncheon told him what could never be disclosed in an inspection of the rodent, however skillfully stuffed in a museum or dissected in a laboratory, so, as the readers of his Colors of Animals well know, Prof. Poulton has discovered much of profound interest in natural history by keeping to the unfenced field so fruitfully scanned by the eye of Charles Darwin. Somewhat as in the case of his great master, his work owes its reward and derives its charm from its inclusive breadth of outlook. Specimens of hornet clear-wing moths might be collected for years, dissected under the microscope with the utmost care, and classified with the nicest precision, without casting a single ray of light on the prime questions, What forces have molded the form and habits of this insect, and why are its hues and markings as we find them? Let the moth, however, be observed in its field of life, and the agencies which have made it what it is come clearly into view. Among the insects which share its woods and meadows will be noticed a wasp; while this wasp neither preys upon the moth nor in any perceptible degree competes with it, the two insects sustain to each other a most vital relation. In its sting the wasp has so formidable and thoroughly advertised a weapon that by closely resembling the wasp the moth, though stingless, is able to live on its neighbor's reputation and escape attack from the birds and insects which otherwise would prey upon it. And so far is the mimicry carried that when the moth is caught in the hand it curves its body with an attitude so wasplike as seriously to strain the nerves of its captor. How came about so elaborate a piece of masquerade? At first, the explanation is, there was a faint gen-

eral resemblance between the moth and the wasp; any moth in which that resemblance was in any degree unusually marked had therein an advantage, and tended to be in some measure left alone by its enemies; in thus escaping it could transmit its peculiarities of form and hue to its progeny, and so on, until in the rapid succession of insect generations, amid the equally rapid destruction of comparatively unprotected moths, the present striking similarity was at last attained. The study of mimicry of this type has from an unexpected quarter afforded singular confirmation of the theory of natural selection ; in many cases the evidence of transformation within comparatively recent time is distinct—in the bee hawk moth, for example, the wings as they emerge from the chrysalis are thinly clothed with scales of ancestral derivation which are shaken off in the insect's first flight, with the result that the bumblebee is the better and more gainfully resembled.

As in the study of insects, so in that of plants—observation in the field at every stage of growth and development is needful to supplement the disclosures of the microscope and the dissecting needle. Many species, of which the milkweed blossom may stand as a type, are absolutely dependent on insects for their fertilization. How, therefore, can they be fully known in the laboratory and the herbarium ? There is no more remarkable adaptation in Nature than that by which an orchid and the insect which continues its race conform to the outlines of each other. And hundreds of flowers less conspicuous than this orchid present perfumes, colors, and mechanism for attracting, seizing, and even imprisoning their insect visitors, which might well be the work of deliberate contrivance instead of inevitable selection from varying scents, hues, and forms of those which prove slightly more serviceable than others. That clover, peas, and other legumes receive their nitrogen from the air has long been suspected by agricultural chemists. The details of the process disclose one of the most curious interdependencies in the realm of Nature. Prof. Hellriegel has discovered nodules on the rootlets of the plants, tenanted by parasitic bacteria, which, while consuming a little of the substance of the plant, pay a handsome rent in the compounds of nitrogen which they build out of the air and pass to the fibers that harbor them. These microscopic purveyors, when bred and sown of set purpose, yield vastly increased crops of clover, alfalfa, peas, cow peas, beans, and lupine. Of this abundant testimony was presented at the Columbian Exhibition in the display of the Experiment Stations in the Agricultural Building.

Here, indeed, we come to the distinctive standpoint whence knowledge sweeps its new horizons: its outlook upon Nature as a whole, as a system intelligible only in the mutual interaction of

its every part, however diverse and remote. It is a drama, not a tableau, which the observer to-day sees spread before him; in that drama every actor has been molded by the part it has had to play to maintain itself upon the stage; every rival, every parasite, every stress of climate with all its influence on food and frame has left its impress; and the ever-threatened doom for irresponsiveness has been the extinction pronounced upon countless forms once masters of the earth. No hue of feather or scale, no barb or horn, no curve of beak or note of song but has served a purpose in the plot or advanced the action in some life story of conflict. When Darwin was confronted in plant or beast by an organ which puzzled him, he was wont to ask, What use can this have had? And rarely was the question asked in vain. In the lunar or weekly recurrent periods of many animal functions there appeared to him a lingering registry of primordial birthplaces; ancestral inhabitants of seashores washed by tides being, in alternate submergence and exposure, profoundly affected in frame and habit.

What is true of the drama of organic life is equally true of the theater in which that drama is enacted. The more thorough its exploration by the geologist, the more extended in time the range of his admissible computations, the more convincing proof does he gather that our planet has become what it is in obedience to forces such as make the world at sunset a little different from the earth that faced the dawn. The hills once called eternal he knows to be anything but changeless, for their very prominence has made them special targets for the fury of tempests, the dividing axe of frost. At the bidding of impulses as irresistible, impulses hidden in the planet's core, a mountain is lifted in a valley's place, and the threatened denudation of a continent by the work of rain and river is silently compensated. And as Prof. Sterry Hunt was accustomed to point out, in the very constitution of the rocks before they bloomed with life, there was prefigured the struggle soon to be illustrated in plant and fish and insect. Amid the wealth of mineral compounds brought to birth only the stablest could survive the ceaseless stress of impinging forces. And these forces as they swept the lifeless globe—how decisive their after influence on herb, and beast, and man! Here, lifting the backbone of a continent, which all the storms of ages should leave a backbone still; there, in mid-ocean bidding an island rise from a volcano's heart; or decreeing a Sahara, or an Australian desert even more forbidding, where only cactus of the hardiest should ever fringe its dust-blown confines. In all this ever-shifting scene of action were laid the foundations of future barrenness of crag or fertility of plain, of that rich variety of earth sculpture in promontory and coast line which has meant so much to humankind.

In the history of the earth the chapter which precedes that written by the geologist is recited by the astronomer, whose key-note also is dynamic. The bulk, inclination, speed, and composition of the earth were all predetermined in the constitution, mass, and motion of the nebula which flung it forth. Dr. Huggins, his spectroscope before him, tells us that were the earth to resume a glowing heat it would yield much the same spectrum as the sun. Clearly, then, the scope of life on land and sea, the architecture of the forest, the ocean and the plain, with all their throbbing life, are what they are because the atoms which built them were present, and in such and such proportions, in the birth-cloud. If a blossom has tints of incomparable beauty, they are conferred by diverse elements thence derived, whose kin aflame in an orb, a celestial diameter away, send forth the beam needful to reveal that beauty. Were the sun less rich in variety of fuel than it is, the world, despite its own diversity of element, would be vastly less a feast for the eye than that which daily we enjoy.

As in the realm of organic life the modern interpretation is no longer static, so also in the sphere of Nature inorganic: it may be that all the thrust, recoil, and interaction in the life of plant and animal lay dormant in the simpler enginery of the atoms and molecules which build their frames and supply their food. It was one of the shrewd guesses of Sir Isaac Newton that the diamond is a combustible body; he did not suspect it to be one with coal in substance, but he observed it to be highly refrangible, as many combustible bodies are. His conjecture shows him to have taken the first step toward the view of modern physicists and chemists—namely, that properties, the modes of behavior of matter, are not passive qualities, but are due to very real activities; that what a substance is depends upon how in its ultimate parts it moves; just as organic structure can be deduced from living function because regarded as the creation of function, or, as in more familiar cases, the character of a die is inferred from its impress, and the construction of a machine read in the work it executes. Clausius and Maxwell, in a theory which marks an epoch, explained the elasticity of gases as manifesting the ceaseless motion of their molecules, declaring that an ounce of air within a fragile jar is able to sustain the pressure of the atmosphere around it, because the air, though only an ounce in weight, dashes against the containing walls with an impact forcible enough to balance the external pressure—proof whereof consists in measuring the velocity with which the air rushes into a vacuum. Here the significant point is that in leaving the realm of mass-mechanics, where the tax of friction is ever present and inexorable, we enter a sphere where motion of the swiftest can go on forever without paying friction the smallest levy. The elasticity of metallic springs has been

similarly explained as kinetic. If we swiftly turn a gyroscopic wheel we can only change its plane of rotation by expending force, which force is repaid when the metal is allowed to resume its original plane of motion. It is imagined that in like manner the particles in an elastic spring move swiftly in a definite plane; if deflected from that plane they oppose resistance and stand ready to do work in returning thereto. Of kindred to the kinetic theory of elasticity is the modern explanation that heat consists in a distinct and ceaseless molecular motion, on which motion, indeed, depend the dimensions of masses. Take a cube of lead or iron from summer air into an ice-house and at once the proportions of the mass begin to shrink. And the molecules themselves, whether of lead, iron, or other element, are imagined by Helmholtz as vortexes born of the ether in which without resistance they forever whirl. As observation proves in the case of a rapidly rotated chain, substantial rigidity can be conferred by motion sufficiently swift. Nor are molecules without something of individuality. We are wont to think of masses of solid iron as precisely similar, but experience proves that one bar or shaft of iron varies from another by all that has differenced the past history of the two. A careful workman uses his die of strongest steel for only a short term of service, well assured that the metal, despite its seeming wholeness, suffers serious internal shocks at every blow—shocks which, were no caution exercised, would soon reveal themselves in fracture and ruined work. In phenomena of this type, which every day confront the electrician and the engineer as well as the mechanic, there seems a prophecy of the sensibility and memory which dawn with organic life.

In the broad field of wave energy the mechanical analogies point to the sway of a single law of motion. If a pendulum is to be maintained in its vibrations, it must receive impulses sympathetically timed—impulses related to its own period of swing as decided by its length. In like manner a piano string vibrates responsively to the note which, when struck, it sends forth; and a gas, such as sodium, when comparatively cool, intercepts in the spectroscopic field precisely those waves which a glowing body of similar gas in the flame of sun or star has radiated. A pane of glass which transmits only the red rays of sunlight, when molten emits the rays complementary to red, and glows as greenish blue. Uncolored glass, which transmits light perfectly, conducts heat badly, because the vibrations are unlike; for the same reason conductors of electricity—the metals, for example—are opaque. The late Dr. Hertz, in generating electric waves intermediate in amplitude between those of sound and light, discovered that opaqueness is a relative term—arm a wave with appropriate dimensions and it has a passport through any substance whatever;

a stone wall or a wooden door becomes as permeable as plate glass to sunshine. All this has long been suspected by the physicists who, among equally significant facts, have noticed that an explosive is set off less by the violence of its detonator than by the sympathy of rhythm between the two. Dr. Lothar Meyer, in his Modern Theories of Chemistry, discusses the ingenious theories which on kinetic principles explain many of the chief qualities of matter—color, refrangibility, volatility, fusibility, and ability to yield heat in combustion. He regards this field as that which bears most promise for the chemical investigator, and follows Berthollet in maintaining that chemistry is but a branch of the larger science of mechanics. In corroboration of this view a thousand facts might be cited—a typical piece of evidence is that adduced by Mr. Witt, who finds that the stability of the azo-benzene dyes turns upon the nicety with which their acid and basic functions balance each other.

In leaving the field of molar for that of molecular mechanics, it has been already noted that friction need no longer be reckoned with; consequences equally important result from the fact that now masses of extreme minuteness are in play. Sir William Thomson (Nature, vol. i. p. 551) has estimated the diameter of molecules as at most $\frac{1}{760000000}$ of an inch in diameter; cubical molecules of this size containable in a cubic inch of space would have a total surface of one square mile and one seventh, which implies that in molecular mechanics superficial forces must count for vastly more than in molar mechanics. Another result follows from molecular minuteness of dimensions—an enormously increased capacity for motion. The smaller a wheel the more swiftly can it be rotated without being parted by centrifugal force, and therefore the more motion can it contain. With a molecule probably, with an atom certainly, centrifugal force has no separating power. How great the momentum of specific molecular motions will appear in computing that due to temperature, in the case of a pound of unfrozen water at the zero of the centigrade scale. According to the determinations of Lord Rayleigh, a pound of water, in falling through one degree of temperature, liberates heat equal to that generated were the mass to fall from a height of fourteen hundred and two feet to the surface of the earth. Therefore, in first becoming ice, and then falling in temperature through two hundred and seventy-three degrees, it parts with an amount of energy equal to lifting the pound of water some fifty-seven and one third miles from the surface of the earth, leaving out of view, for simplicity's sake, the diminution in the attraction of the earth as the mass is lifted. Prof. Dewar, in his recent remarkable experiments at a temperature of 200° below zero, has found reason to believe that at absolute zero the electri-

cal resistance of metals would disappear; cooled to the temperature of liquid oxygen, the red oxide of mercury becomes yellow, and both sulphur and bichromate of potash turn white.

Surprising as are the figures which denote the molecular motion due to the temperature of water, more surprising still are the computations which declare the chemical energy in the gases which unite to form water. Measuring the heat liberated in their union, it is found that the molecules of hydrogen and oxygen possess as chemic motion energy equal to lifting the masses involved some eleven hundred miles from the surface of the earth. It is imagined that the molecular motions representing temperature, chemical affinity, electrification, or other energy, coexist without confusion, just as air sustains, in perfect order, the superposed harmonies of an orchestra and chorus. The extremely rapid motion of molecules, acting at their comparatively vast surfaces, must immensely exalt forces which, between masses, are but feeble. A simple model may help to make this clear. Let two cylindrical wheels, similar in all respects and covered with rubber, be brought into contact on a floor—they will in a slight degree adhere; let the wheels be swiftly turned in a direction toward each other, and they will press each other with considerable force—force proportionate to their speed, which force at high speed will exalt their weak adhesion to somewhat of the intensity of cohesion as manifested between molecules. The model can illustrate something more: as a unit it does not change its place, albeit that its halves are in rapid motion; were its dimensions too small for microscopic view, the motion of its parts would be undetected, and, because the motions would balance each other, a mass built up of such pairs of molecules would be in seeming rest.

While the chemists are busy disentangling the orbits in which swim the atoms and molecules of the laboratory, the physicists are equally active in endeavoring to reduce to mechanics the various phases of energy. Here the first and decisive step was taken when the revelations of form and color to the eye were explained as borne by ethereal waves, which follow one another at a rate so prodigious as to yield the impression of rest; which explanation, indeed, had long been suggested in the phenomena of sound where air-waves are palpably concerned. The notable points of agreement in both spheres of action are that a medium can transfer motion as perfectly as if the two bodies connected by it were in immediate contact; moreover, that the efficiency of the medium increases as its density diminishes; and that the medium itself exacts no toll whatever, relapsing when its work is done into the seeming rest from which its task awakened it. With apparatus acoustic in model, the late Dr. Hertz, of Bonn,

demonstrated that light and electricity differ from each other only as short waves differ from long ones; presumably the same medium serving as the vehicle for both. His masterly experiments thus disclosed another bridge between modes of motion which less than a century ago were accounted distinct and unconnected.

While the establishment of the truth of the conservation of energy justly ranks among the grandest achievements of human thought, that truth would be rounded into satisfying completeness were it proved that energy in all its forms is motion and nothing else. The obstacle here is that gravity does not lend itself to any kinetic theory thus far framed. And this notwithstanding that atomic weight is the fundamental characteristic of matter, so that, indeed, it conditions every property of a substance—proof of which arrived in the fulfillment of the predictions of Mendelejeef, who, taking this theory as his finder-thought, foretold that scandium, gallium, and germanium would be added to the list of chemical elements, and would be found to possess properties which he detailed. Gravity is marked off from other phases of energy by two characteristics—if it be transmitted through space as are other modes of motion, it either travels instantaneously, or so fast as to elude the observation of astronomers competent to detect its movement were it fifty million times as swift as light. Quite as remarkable is the fact that a mass may be heated, electrified, magnetized, or chemically transformed without its weight being affected in the slightest degree. This in striking contrast with the action of heat, which modifies the color, chemical activity, conductivity, and other properties of a substance, and its volume as well. The only analogy which gravity bears to other forms of energy is that which it sustains to electricity and magnetism, and were these forces attractive only, the analogy would be a close one. But let us trace what analogy there is and we may find it helpful. In the manufacture of a common steel magnet the palpable motion of a dynamo disappears to create its attraction; the imparted dynamo motion therefore is imagined as continuing in full actuality in the molecules of the magnet. When an armature is brought within the magnet's field it is attracted—that is, it powerfully tends to move toward the magnet; until that impulse is satisfied a space divides armature and magnet. All the analogies of light and electricity, proved to be fundamentally one with magnetism, bid us believe that between magnet and armature a medium is actively concerned in bringing both masses together; why may not a similar, or that identical, medium be active in bringing from a tree an apple to the earth? What is needed here is investigation of how the motion of a molecule in its own orbit, or on its axis, becomes

a movement of translation. A wheel, if frictionless like a molecule, could revolve on its bearings forever; if it were small enough, its motion would forever escape observation. Were it dropped from its bearings, through however short a distance, to a horizontal plane, part of its energy would be at once expressed in its advancing in a line long enough for detection. The question behind attraction and repulsion is, How shall two distant bodies move on their axes, or in their orbits, so as to act on a chain of intervening bodies with the effect that the two shall approach or recede from each other? This problem does not seem to present insuperable difficulty to the inventiveness which has built so many models illustrating the architecture of the molecule, showing how, in all probability, the links subsist between the atoms of an alcohol or an ether.

One after another various forms of energy once called potential have been brought into line with energy actual, have been reasonably explained as meaning nothing more or less than motion; is it not time that old conceptions of motion should be expanded so as to include the phenomena of gravity as well as all the others once deemed to consist in mere "advantage of position"? Gravity can be imagined as a special molecular motion in its propagation either instantaneous or too swift for existing means of measurement. This supposition may be an unwelcome one, but what is the alternative? Whereas the physicist of to-day holds that the chemical energy of such an element as carbon, the elasticity of a coiled spring or of a confined body of gas, and the quality we call temperature, all denote real activities, nevertheless, the lifting of a weight, into which any of these activities can be readily transformed, is not represented by motion at all, but by an ultimate and unnamed something else. Whether is it better to cherish a conception in its inherited form or to try to broaden it as the facts demand? For the inclusion of gravity among the phases of veritable motion there is cumulative suggestion. When in every other phase of energy there is either detection of motion in what seeems rest, or an assumption of motion the validity of which is proved in the fulfillment of the predictions to which it leads, the hint is clear. It is that gravity, too, will be demonstrated as motion by future means of inquiry which may as far transcend our present resources as these surpass the methods of the men of science who, not so very long ago, could bring forward reasons for believing phlogiston to be a substance and electricity to be a fluid.

The advance of knowledge thus far has been a process of identification. Heat, chemical affinity, electricity, magnetism, and all the other forms of palpable energy are now held to differ from one another only as do the circles, spirals, and straight lines de-

scribed by the wheels and levers of the machine shop. In an ever-extending curve the physicist has arranged a continuous series of real activities, a wide diversity of energies once deemed "potential," static, at perfect rest. Is it reasonable to maintain that this curve of his, almost a full circle, does not form part of a real circle, that the small arc which yawns where gravity can fit with the completing effect of a keystone, represents a discontinuity in the nature of things? Preferable, because more probable, is the idea that the scope of kinetic explanation is universal, that the whole scheme of physical Nature represents in its every part and function an enginery upon whose ceaseless action hinges the drama, ever more involved, of plant and animal and human life.

To men who knew only what had befallen themselves and their dwelling place during a few generations, it was but natural to repeat: "The thing that hath been, it is that which shall be; and that which is done, is that which shall be done; and there is no new thing under the sun." * But we of to-day are in different case. The astronomer, joining camera to telescope, expands the sphere of the known universe a million fold; he discovers system after system in stages of life such as our sun and its attendant orbs have passed through in ages so distant as to refuse conception. The geologist, deciphering the birth register of our planet's oldest rocks, gives them a lifetime scarcely to be distinguished from eternity. The range of time, thus broadened, permits to the smallest arc of change a sweep wherein it becomes a circle of profoundest transformation. The naturalist, his tasks of mere description almost at an end, finds their chief value to lie in their furnishing data for the new question, How did all this diversity of life become what it is? Ever the keynote of reply is action and reaction, unending stimulus and response. Permanence is only a seeming, the truth behind it is universal plasticity and change. In the organic world this passing from appearance to cause has restored soul to body, and made intelligible for the first time both form and substance, by referring them to the forces which mold and inform every material frame of life. In the inorganic world it will be the same; the force which binds sun to planet, pebble to seashore, will yet be understood as part of the unbroken round of all-comprehending motion.

The pterodactyls, it appears, are not yet all dead. Mr. E. M. Magrath says, in the London Spectator, that a small flying lizard is still to be found on the southwestern coast of India, of which he had some stuffed specimens—given away, however, years ago, to a distinguished naturalist.

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* Ecclesiastes, i, 9.

THE NOCTURNAL MIGRATION OF BIRDS.

By FRANK M. CHAPMAN.

NO branch of ornithology offers more attractions to the student of birds than the fascinating subject of migration. Birds come and go; absent to-day, to-morrow they greet us from every tree and hedgerow. Their departure and arrival are governed by as yet unknown laws; their journeys through the pathless sky are directed by an instinct or reason which enables them to travel thousands of miles to a winter home, and in the spring to return to the nest of the preceding year.

Volumes have been written to explain their mysterious appearances and disappearances.

Theories almost as numerous as the essays themselves have been advanced to account for the phenomena of migration. From the time of Jeremiah (viii, 7) to the present day we might cite a host of authors who have contributed to the literature of the subject. It is not our intention, however, to review the whole question of migration. The combined researches of ornithologists have placed it among the sciences, and its more prominent facts are common knowledge. We desire here to call attention to but one phase of the study, and more especially to outline some recent investigations in connection with the nocturnal migrations of birds.

From the nature of the case, our data concerning these night flights have long been meager and unsatisfactory. Even now our information has but reached a stage which permits us to intelligently direct further effort.

We know that the land birds which migrate by night include species of more or less retiring disposition, whose comparatively limited powers of flight would render them easy victims for birds of prey if they ventured far from the protection of their natural haunts during the day. Thus we find that the bush- or tree-loving thrushes, wrens, warblers, and vireos all choose the night as the most advantageous time in which to make their long semi-annual pilgrimage, while such bold rovers as swallows, swifts, and hawks migrate exclusively by day.

The information we possess concerning the manner in which the first-mentioned class of birds accomplish a journey which leads them from boreal regions to the tropics, has been derived from three sources: First, through the birds which are killed by striking lighthouses or electric-light towers; second, through observations made at night from similar structures; and, third, through the use of the telescope.

It has long been known that lighthouses are most destructive

to night-migrating birds. Probably no one artificial cause produces more disastrous results than these beacons which guide the mariner in safety, but prove fatal obstacles in the path of aërial voyagers.

The number of birds killed by striking lighthouses is incalculable. Over fifteen hundred have been found dead at the foot of the Bartholdi Statue in a single morning; while from Fire Island (Long Island) light we have a record of two hundred and thirty birds of one species—black-poll warblers—which met their fate on the night of September 30, 1883.

Reports from numerous lighthouses show (1) a great variation in avian mortality at different localities; (2) that as a rule no birds are killed during clear nights; and (3) that comparatively few birds strike the lights during the vernal migration. The fact that birds follow certain routes or highways of migration in their journeys to and from the South doubtless explains their absence or presence at a given locality; indeed, it has been definitely ascertained that lights which are situated in known lines of migration—as, for example, the Bartholdi Statue at the mouth of the Hudson River Valley—prove far more destructive than those which are placed far from the regular routes of migrating birds.

Through telescopic observations, to be mentioned later, we have learned that when *en route* birds travel at an altitude of from one to three miles above the earth. It is obvious, then, that when their way is not obscured by low-hanging clouds they pass too far above us to be attracted by terrestrial objects. It has been noted that cloudy and especially rainy nights are most disastrous to migrants, evidently because the formation of moisture at the elevation at which they are flying must not only interfere with their progress, but in veiling the earth below robs them of their landmarks, while the condensation of this moisture into rain presents an effectual check to flight. The birds then descend to a lower altitude, and, should the storm be very severe, they are obliged to seek the nearest shelter, and even may be driven to earth wet, helpless, and dying.

The influence thus shown to be exerted by meteorological conditions is the best explanation of the comparatively small number of birds killed during the spring migration, when the infrequency of violent storms enables them to perform their journey with less danger from exposure to the elements.

The observations of Mr. William Brewster on the migration of birds at the Point Lepreaux (Bay of Fundy) lighthouse have never been exceeded in interest or value by the recorded experiences of any other observer of similar phenomena. Still, even his graphic account fails to produce the sensations which possess

one when for the first time the air at night is actually seen to be filled with the tiny songsters which before were known only as timid haunters of woods and thickets.

On September 26, 1891, it was the writer's good fortune to pass the night with several ornithologists at the Bartholdi Statue in observing the nocturnal flight of birds. The weather was most favorable for our purpose. From the balcony at the base of the statue we saw the first bird enter the rays of light thrown out by the torch one hundred and fifty feet above us at eight o'clock. During the two succeeding hours birds were constantly heard and many were seen. At ten o'clock a light rain began to fall and for three hours it rained intermittently. Almost simultaneously there occurred a marked increase in the number of birds seen about the light, and within a few minutes there were hundreds where before there was one, while the air was filled with the calls and chirps of the passing host.

The birds presented a singular appearance. As they entered the limits of the divergent rays of light they became slightly luminous, but as their rapid wing-beats brought them into the glare of the torch they reflected the full splendor of the light, and resembled enormous fireflies or swarms of huge golden bees.

At eleven o'clock we climbed to the torch and continued our observations from the balcony by which it is encircled. The scene was impressive beyond description; we seemed to have torn aside the veil which shrouds the mysteries of the night, and in the searching light reposed the secrets of Nature. As the tiny feathered wanderers emerged from the surrounding blackness, appeared for a moment in the brilliant halo about us, and continuing their journey were swallowed up in the gloom beyond, one marveled at the power which guided them thousands of miles through the trackless heavens. While by far the larger number hurried onward without pausing to inspect this strange apparition, others hovered before us like humming birds before a flower, then wheeling retreated for a short distance and returned to repeat the performance or pass us as did the first class mentioned, while others still, and the number was comparatively insignificant, struck some part of the torch either slightly or with sufficient force to cause them to fall stunned or dying. It was evidently by the merest accident that they struck at all; and so far as we could judge they were either dazzled by the rays of the light and thus unwittingly flew directly at the glass which protects it, or came in contact with some unilluminated part of the statue. During the two hours we were in the torch thousands of birds passed within sight, but less than twenty were killed.

This fact, in connection with the comparative or entire absence of birds on clear nights, very plainly shows that conclusions based

solely on these casualties may be not only misleading but erroneous. In other words, the number of birds which strike a light is a poor index to the number which have flown by or above it in safety.

Throughout the evening there was a more or less regular fluctuation in the number of birds present; periods of abundance were followed by periods of scarcity, and the birds passed in well-defined flights, or loose companies, probably composed in the main of individuals which had started together.

The birds chirped and called incessantly. Frequently, when few could be seen, hundreds were heard passing in the darkness; the air was filled with the lisping notes of warblers and the mellow whistle of thrushes, and at no time during the night was there perfect silence. At daybreak a few stragglers were still winging their way southward, but before the sun rose the flights had ceased. The only birds identified were several species of warblers and thrushes, one red-eyed vireo, two golden-winged woodpeckers, one catbird, one whip-poor-will, and one bobolink. The most interesting and important results of the night's observations were, the immediate effect of rainfall in forcing birds to migrate at a lower level, the infrequency with which they struck the torch, the immense number which passed beyond its rays, and the constancy with which they called and chirped as they flew.

An almost virgin field awaits the investigator who will systematically observe night-migrating birds with the aid of a telescope. Messrs. Allen and Scott, at Princeton, and the writer, assisted by Mr. John Tatlock, Jr., at Tenafly, New Jersey, and at the Columbia College Observatory, have alone recorded the results of observations of this nature. Their labors, however, were too brief to more than show the possibilities which await more extended effort.

A comparatively low-power glass is focused upon the moon, the birds appearing silhouheted upon its glowing surface as they cross the line of vision. Some idea of the multitude of feathered forms which people the upper regions of the air at night may be formed when it is stated that during three hours' observation at Tenafly no less than two hundred and sixty-four birds were seen crossing the restricted field included in the angle subtended by the full moon. Under proper focal conditions, birds were so plainly visible that in many instances marked character of flight or form rendered it possible to recognize the species. Thus ducks, snipe, and sora rail were distinguished with certainty.

The effect on the observer of this seeing of things unseen is not a little curious, and may be likened to the startling disclosures which a high-power microscope presents in a drop of water.

From calculations based on an assumption that birds were not

visible beyond a distance of five miles, we determined the greatest altitude at which birds migrate to be three miles above the earth's surface. Many, however, fly at a lower level; indeed, it is not improbable that certain species may, with more or less regularity, travel at a given altitude, and that this altitude may vary among birds of different families. With little doubt thrushes and warblers travel at a much lower level than do ducks and geese, a circumstance which may account for the great abundance of the first two named and the comparative absence of the last in the vicinity of lighthouses.

Such, in brief, are the sources and methods to which we owe our knowledge of the nocturnal flight of birds. It will be evident to the most casual reader how incomplete are our data. The time is still far distant when we can hope to conclusively account for the many perplexing phenomena of migration, but we may be pardoned if, in conclusion, we briefly review the bearing of our present information.

We need not discuss here the origin of migration or the causes which now induce birds to undertake a long and perilous journey twice each year. But the power and influences which guide a bird, in the darkness of the night, through space, and render a definite migration possible, are subjects kindred to our inquiry and worthy our attention.

Until we possess some exact knowledge of the distance to which birds can see we can not estimate the aid their vision is to them while migrating. We know, however, that the avian eye is far more powerful than ours, and it is fair to assume that to some extent their journeys are directed by a sight which enables them to follow mountain chains, river valleys, and coast lines, and to distinguish distant headlands or islands. At an altitude of two miles an object would be visible ninety miles and the horizon be separated by twice this distance. At no time, therefore, in their journey from North to South America are birds necessarily out of sight of land. But that they do venture beyond a point where land is visible is shown by the regular appearance of migrants in the Bermudas, six hundred miles from our coast, while Jamaica, four hundred miles north of the nearest point of South America, is a point of departure for many south-bound migrants. Here, with neither islet, shoal, nor reef to mark the way, it is evident that sight alone would prove an insufficient guide, and they must rely on some other sense. Primarily, this is the inherited habit which prompts birds to fly southward in the fall and to return in the spring. But, given the impulse of direction, there is little doubt that one of the best guides to night-flying birds is the sense of hearing. Birds' ears are exceedingly acute. They readily detect sounds which to us are inaudible. Almost invariably

they will respond to an imitation of their notes. We have seen that when under way they constantly chirp and call, and when we take into consideration their aural power and their abundance in highways of migration, it is probable that at no time during the night is a bird out of hearing of its fellow-travelers. The line of flight once established, therefore, presumably by the older and more experienced birds, it becomes a comparatively easy matter for the novice to join the throng.

MODERN VIEWS AND PROBLEMS OF PHYSICS.

By DANIEL W. HERING, C. E.,
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A GOOD idea of the generally accepted views upon a science in all its branches may be obtained by inspecting standard text-books on the subject, for such works are not likely to meet with the approval of scholars, and especially of professors, if they present views that are antiquated in form or palpably erroneous in statement.

In thus approaching a modern text-book of physics, to a beginner, or one with no preconceived ideas on the subject, there would perhaps appear nothing surprising, but to an older student, say the college alumnus of fifteen years' standing who has not kept abreast of the science, the change would be striking. He would probably be impressed as much by the absence of things he had thought inseparable from the subject as by the presence of things of which he heard little or nothing in his college course. An illustration of this may be seen in a very recent book of the kind named.* In its general tone it is similar to that adopted about ten years earlier in the masterly presentation of the Principles of Physics, by Prof. Daniell, but it is less conservative than that work. A glance at the headings gives the keynote of the whole treatment. After a brief discussion of kinematics and dynamics, *mass physics* is further divided into work and energy, attraction and potential, properties of matter, energy of mass vibration, sound. Then physics of the ether has energy of ether vibration, radiant energy, energy of ether stress, electrostatics, energy of ether vortices, magnetism, energy of ether flow, electro-kinetics, electro-magnetic character of radiation.

There is not an allusion to the old familiar "simple mechanical powers"; there is no mention of light or optics as a branch of physics; sound, heat, electricity, and magnetism are only ap-

* Barker's Advanced Physics.

pended as subtitles to more general terms expressing forms of energy, and appended in a way that would permit them to be dropped altogether without detriment to the treatment of their phenomena. Not that the phenomena are different from what they were in former times, but they have become much more effectually correlated in a general scheme of energy. Such a mode of presenting the subject might be ascribed to a mere desire to break away from conventional lines, but it is in strict accord with the work and conclusions of physicists generally in the last quarter of a century and especially within the last decade. Physicists accept fully the mechanical theory of heat. They regard the heat of a body as the aggregate kinetic energy of the molecules. They accept in general the kinetic theory of gases, but are not uniform in their views as to the extension of this theory to liquids and solids. In the mechanical theory of heat, however, the idea that all the molecules of all bodies are in motion is fundamental. Nowadays, instead of ascribing phenomena to the action of mysterious "forces," with perhaps a force of one kind for gravity, of another kind for thermal or electric or magnetic effects, and treating force as a real agent bringing about changes, it is the custom to recognize in any body or system of bodies a certain quantum of energy of which the form or distribution is altered by a change in the form or configuration of the body or system of bodies. Energy is the thing studied and force is merely the rate at which the energy of a body is altered in comparison with the change in the position or shape of the body. The term force is still in use for convenience and brevity, but the objectivity of force has disappeared. Force is not a real thing at all, but energy, like matter, has an objective existence. Also, when force was regarded as an agent, it was discussed as acting at a distance without regard to a medium for transmitting action from one body to another, or, as we now say, for conveying energy. But if bodies possess and exchange energy, and energy is only perceived by us in connection with matter, we find it proper not only to recognize a medium throughout space, but to discuss the forms in which energy exists in that medium, which is spoken of as ether. The idea of such a medium is not modern. After pointing out that the hypothesis of an ether was a device often resorted to for the purpose of mystification as much as explanation, Maxwell says: "Ethers were invented for the planets to swim in, to constitute electric atmospheres and magnetic effluvia, to convey sensations from one part of our bodies to another, and so on, until all space had been filled three or four times over with ethers. It is only when we remember the extensive and mischievous influence on science which hypotheses about ethers used formerly to exercise that we can appreciate the horror of ethers which sober-

minded men had during the eighteenth century. . . . The only ether which has survived is that which was invented by Huygens to explain the propagation of light." *

Those ethers were working hypotheses which might be expected to give way wholly or in part to better ones constructed for working purposes under fuller knowledge. So, too, at first, was the luminiferous ether, which, as a hypothesis, had to be endowed arbitrarily with properties suited to the phenomena it was to account for, but *the ether* of modern science is accepted as beyond question. For example, Lord Kelvin says: ". . . This thing we call the luminiferous ether. That is the only substance we are confident of in dynamics. One thing we are sure of, and that is the reality and substantiality of the luminiferous ether." † It is not necessary here to go into the evidences of its reality, but our belief in it rests upon exactly the same kind of evidence and just as strong evidence as does our belief in the existence of any kind of matter. For we only infer the existence of any form of matter from its phenomena, and the phenomena of light, heat, magnetism, and electricity to the extent of a very large group are not only explainable but are best explainable by the assumption of the ether. The defect as yet in such an assumption lies in the fact that the ether is a substance of an unfamiliar kind. It is this want of familiarity that physicists to-day are doing their utmost to overcome, and the more it is examined the more are they impressed by the multiplicity of purposes which this one medium is competent to serve and which it seems to be serving. The time for doubting its existence is past—it is now only a question as to its nature and properties; and it is accepted as a fact, not merely a hypothesis, that the same medium is concerned, if not a principal factor, in the phenomena of light, heat, magnetism, electricity, and gravitation. Radiant heat and light are wave motion in the ether, and are similar forms of energy, the only difference being in the period of vibration. Their manifestation as energy only occurs when the vibrations affect matter, and this, the most difficult part of the subject, involves the relation between ether and ordinary forms of matter. We say "ordinary forms" of matter, because ether may or may not be considered a form of matter.

One of the great, the primary questions of science is, What is ether? The question, What is light? has found its answer, so too has the query as to heat and as to sound; as to electricity, not so assuredly or so definitely, but both it and magnetism are to find their explanation through this same medium in some way or

* Article on Ether in the Encyclopædia Britannica.

† Popular Lectures and Addresses, by Sir William Thomson, vol. i, p. 317.

other. There is no longer any doubt about that, and Maxwell's theory, which rests upon this idea fundamentally, has a strong hold upon modern science and a hold that is growing stronger as research advances.

We know the ether as a vehicle of energy in several forms, and when various agencies are collected into a group of forms of energy there is still the question, "What is energy?" These general problems now engaging the attention of the physicist—viz., the ultimate nature of matter, by which the properties of matter may be accounted for; the nature of the ether and its properties; the mutual relations subsisting between matter and ether, if they are different things; the nature of energy, and whence it arises, and whether it is primarily potential or kinetic—these, in part at least, are not new problems, but they are now approached from new directions, along new ways, and by the aid of new light. Under each of these heads appear numerous special questions, and along all these lines investigators are working earnestly.

The attempt to explain the nature of ether or of matter at once raises the question whether ether is matter. Now, of course, a great deal depends upon the definition of terms, and it is perhaps best to confine our attention at first to the structure of matter rather than its nature. The properties and behavior of matter as it is ordinarily recognized are largely known, the actions and functions of the ether are largely known, and it is only a question of the propriety or possibility of including both in one general view. Clerk Maxwell * regards as a proper test of a material substance its ability to contain and transmit energy. He then points out that energy can not exist except in connection with matter; that in the space between the sun and the earth, the luminous and thermal radiations which have left the sun and which have not reached the earth possess energy in definitely measurable amount, and therefore this energy must belong to *matter* in the interplanetary spaces. On the other hand, Prof. Dolbear stands as an exponent of the views of others who decline so to class the ether when he says: "If, then, the ether fills all space, is not atomic in structure, presents no friction to bodies moving through it, and is not subject to the law of gravitation, it does not seem proper to call it matter." † But Prof. Dolbear has previously announced as his criterion of matter, the possession of the property of gravitative attraction. On such grounds we may concede each view to be correct, but we are brought at once to the old question, "What is matter?" It is the view of some that, with the present limitations of intellect, it is beyond

* Matter and Motion.

† Matter, Ether, and Motion.

our powers ever to conceive of the ultimate nature of matter. Of the structure of matter this is not the case. Various hypotheses have been offered regarding the structure of matter—all, save one, have been charged with some fatal objection and have broken down. This one, the suggestion of that powerful mind, Lord Kelvin's, is known as the vortex-ring theory. We can not give it here in any detail, but the gist of it is that the ether is universal and for the most part formless, but that some parts are differentiated from the remainder by being in motion in the shape of vortex rings. These parts in such rotational motion are matter in the ordinary forms. A remarkable thing about it, and one which exhibits the very spirit of modern physics, is that those properties of ordinary matter which emphasize its stability of form and position, especially inertia, elasticity, and rigidity, *can be a result of motion.* Yet Lord Kelvin has shown that with ordinary matter a limp system of bodies could be made a rigid system by merely putting them into gyroscopic rotation, and also that elasticity itself might properly be regarded as a mode of motion. The vortex-ring theory is as yet only a speculation, but when its adaptability to occult as well as to plainer properties of matter are considered, we need not wonder that it has been thought so beautiful that "it deserves to be true." At any rate it stands in such an attitude toward modern views concerning the structure of matter that "it is either that theory or nothing. There is no other one that has any degree of probability at all" (Dolbear). We can see how such a theory might reconcile conflicting views such as those above given concerning matter and ether separately.

Without waiting for a decisive answer as to the nature of ether or the structure of matter, attention is being concentrated on the relations of one to the other, the extent to which and the manner in which any change in either substance affects the other; and this examination may throw light upon the greater question regarding the nature of the substances. Do material bodies moving in the ether of space—for example, the earth and its atmosphere—move through the ether, or carry with them the ether that is distributed throughout the matter that is moving? Experiments of extraordinary precision by Prof. Michelson have led him to conclude that most probably the earth carries with it all the ether in its immediate neighborhood; that certainly the relative motion of the earth and the ether in it is exceedingly small. If he can repeat his experiments and get a different result on the top of a mountain, that conclusion may be considered established. Those conclusions were drawn from experiments in which the earth's velocity in its orbit is involved. Prof. Lodge has experimented for effects due to slower motion of bodies upon

the earth. He says: "I do not believe the ether moves. It does not move at a five-hundredth part of the speed of the steel disks" (used in the experiment). "I hope to go further, but my conclusion so far is that such things as circular saws, fly wheels, railway trains, and all ordinary masses of matter do not appreciably carry the ether with them. Their motion does not seem to disturb it in the least."

Among the more special questions undergoing investigation at present by the application of physical principles is the determination of the relative motion of the heavenly bodies by spectroscopic methods. It is done by applying to light-waves what is known in acoustics as Doppler's principle. The position of any line of the spectrum depends upon the wave length, or, what comes to the same thing in this case, the period of vibration for the particular set of waves making the light at that line in the spectrum. By increasing the number of waves per second that fall upon the prism (or grating) of the spectrometer, the period is correspondingly decreased, and conversely. Therefore, while the rate of vibration remains constant, if the grating is moving toward the source of vibration, the number of waves per second falling upon the grating will be greater, and their period smaller, than if the source and the grating are stationary relatively to each other. If they are separating, the period of vibration is increased. In the former case the line of the spectrum will be more refracted, in the latter less refracted, than in a normal case. When a spectrum line of any of the heavenly bodies has been identified with that of any substance known to us, the spectrometer gives the means of determining the motion of such heavenly bodies as compared with the motion of the earth, by observing the displacement of the spectrum line. That is, it is possible to determine whether the earth is approaching the star or nebula or receding from it, and at what rate. This method was proposed and attempts were made to apply it very early in the history of the spectroscope, but the means of observation were not then sufficiently fine, and only negative results were obtained. Within the last few years, however, Prof. Huggins, Prof. Vogel, and others in Europe have made many successful measurements of this character, and Prof. Keeler, of the Alleghany Observatory, has greatly extended them. These relative motions are usually reduced to the sun, the results indicating the relative motion of the sun and the heavenly body observed. As instances, Prof. Keeler finds that the great nebula in Orion is receding from the sun at the rate of eleven miles per second; and by observations between April and August, 1890, the sun was at that time approaching the bright star Arcturus at the rate of four miles and three tenths per second. These serve as a fine illustration of modern methods

of research and the degree of precision attainable. The trustworthiness of the method is shown by the close agreement between its results when applied to the other planets, and the velocities computed from the known astronomical motions of the same bodies.

It is usually thought necessary to caution students of electricity against regarding either of the hypotheses, known respectively as the two-fluid and the one-fluid hypothesis, in the light of an assured thing, and the lecturer commonly hastens to declare that no one knows what electricity is. The declaration is as just as the caution; but it is not in human nature to allow such a declaration long to stand unchallenged. The very fact that it is possibly correct is a stimulus to investigation. Recent research has not conclusively shown what electricity is, but it has considerably shaken the foundations of the above assertion regarding it, and some singular views have been developed that indicate light ahead. We are learning that although the terms "electrification" and "electric" may continue in service to express a condition of matter or to characterize particular phenomena, yet the very name "electricity" may probably become useless and vanish from the vocabulary of physics, for the reason that, instead of electricity being any object, it is probably only a mode in which the ether makes itself manifest. One of the latest views, strongly advocated, is that ether may be analyzed into two constituents, equal and opposite, each endowed with inertia and each connected with the other by elastic ties which are weakened or dissolved by the presence of gross matter. The two constituents are called positive and negative electricity respectively, and of these two electricities the ether is composed. Electric currents which are obtained in such diversity and magnitude for commercial purposes are in almost every case the result of electro-magnetic induction, and are not due to the action of a battery. Yet there is no difference electrically between the currents obtained in the two ways. Maxwell's theory, which treats electro-magnetic action as a variation of ether stress in the medium in which the conductor is situated, may be applied to the conductors of battery currents also, and the medium surrounding the conductor in all cases is the home of the energy transmitted (as we are in the habit of saying) along the wire. But the energy is not transmitted by the wire; on the contrary, the wire, in just so far as it is a good conductor, fails to transmit the energy (the strain) which the action of the generator has sent out into the surrounding medium, and which breaks down or gives way in the conductor. "The energy of a dynamo does not, therefore, travel to a distant motor through the wires, but through the air. The energy of an Atlantic cable does not travel through the wire strands, but through the insulating

sheath. This is a singular and apparently paradoxical view, but it is well founded" (Lodge). And even as to the power of a wire to conduct whatever it does conduct, a special feature has risen into considerable prominence. The most important principle for many years in the study of electricity has been Ohm's law, which states that the resistance of a conductor may be measured by the ratio of the electro-motive force to the current strength. This law when first enunciated was scrutinized closely, demurred against by some experimenters, and shown mathematically to be impossible if carried to extreme applications; it was re-established and experimentally and mathematically proved correct, chiefly by Kirchhoff's work; and is now known to be inaccurate as an expression of the effect transmitted (or resisted) by a conductor under rapid alternations of current, so that to express the energy transmitted under such circumstances another factor has to be taken into account besides what is usually regarded the resistance. This additional quality is called the *impedance*, and the total resistance of a circuit carrying periodic currents is made up of the ohmic resistance and the impedance. The latter has no value when the current is steady, but has reference only to the time while the current is rising from zero to its maximum strength. The principle of impedance was known a good while ago, but it has only demanded the attention of electricians since the alternating currents have begun to be employed on any considerable scale. Ohm's law is just as true as it ever was, but the limitations of its applicability are now better recognized than formerly.

A rapid succession of electric discharges sets up strains and relaxations in a non-conducting medium, which result in the propagation of waves of electro-magnetic induction through it. With oscillations of great frequency, the waves become short enough to be observed and measured readily, and the recent experiments of Hertz show so many features of similarity in the laws and phenomena of reflection, refraction, and speed of transmission of these waves and of light as to sustain Maxwell's theory of the electro-magnetic character of light.

Advances in science are often the outcome of efforts to apply its principles in the arts. A great problem of physics which engineers have to solve is to find economical means of utilizing the energy that Nature is ready to furnish in place of the present wasteful ones. The inefficiency of the best steam engine is a standing reproach to an inventive age. The reproach is to be removed not by the improvement of the steam engine—for its limitations are such that, in the nature of things, it can not be highly efficient—but by the substitution of a better type of machine. Ether vibrations bring us energy in the form of heat, light, or electricity, ac-

cording to their periods and amplitudes; but these, instead of being available in any particular form, are always more or less complex. If we could produce waves of just the rate and amplitude we desire, without any others in combination, a great step would be gained. Then we could produce light without wasting at the same time a great amount of energy in producing heat which we do not want. This is one of the subordinate problems awaiting solution. If to the production of such waves as are wanted we could add a means of recording and fixing them in their true relative proportion, we would have the solution of another great and fascinating subordinate problem—the exact reproduction of natural scenes in color. A long step has been taken toward accomplishing the first of these achievements in the remarkable experiments by Mr. Tesla with alternating electrical currents of high frequency and high potential. Among the startling facts brought out in these experiments is that although a current of electricity, either direct or alternating, from ordinary dynamos under fifteen hundred or two thousand volts electro-motive force will kill, yet under alternations of a million to a million and a half per second a voltage of fifty thousand produces no shock or injury. Electric lamps light with but a single wire leading to them. Vacuum tubes become luminous in a properly prepared room with *no wires*, and it is not extravagant, in view of what has already appeared, to predict a future when unlimited power will be available at every man's hand. That will be when, as Mr. Tesla says, we are able to "hook our machinery to the machinery of Nature." In the conclusion of his lecture before the Institution of Electrical Engineers, London, after describing a plan by which he thinks it would be practicable to telephone across the Atlantic, he adds: "But such cables will not be constructed, for, ere long, intelligence—transmitted without wires—will throb through the earth like a pulse through a living organism. The wonder is that, with the present state of knowledge and the experience gained, no attempt is being made to disturb the electrostatic or magnetic condition of the earth, and transmit, if nothing else, intelligence." It is probable that this wonder will give place to a still greater at no distant period, by reason of successful attempts of just the kind here mentioned. The problem is already in course of solution, the distinguished electrician, Mr. Preece, having recently succeeded in sending telephonic messages over a circuit which was wholly disconnected from that in which the generator was placed, and at a distance of three miles from it.

Unquestionably one of the most powerful aids to investigation of late has been photography. Both as a science and as an art it has grown in precision, speed, and availability, until now it has become a weapon of attack as well as a means of record. While

owing more itself to chemistry than to physics, in the latter especially has it been of assistance to the spectroscope, so that the experimenter is not dependent upon the observations of the moment to make his comparisons. The most considerable work of this kind has been done by Prof. Rowland within the last half-dozen years, in making remarkably large and detailed photographs of the solar spectrum, the spectrum itself, in its perfection and beauty, being due to the matchless gratings constructed under Rowland's directions. Photography has proved to be an unassailable recorder for all the natural sciences, and is likely to become more and more firmly established as such. Disputes over priority in discovery will become less frequent since investigations made in solitude will appeal to their photographic record as a safe witness, impartial and indisputable.

Another subordinate problem is to determine the intensity of sound in absolute measure. Acoustics has been studied with reference to the energy involved less than other branches of physics, although we easily recognize some transformations of such energy into mechanical in the phonograph and electrical in the telephone. But most determinations of the intensity of sound have been relative, by comparison of different sounds, or else the same sound at different distances or in different media. They have not been expressed in absolute units. Absolute values of radiant energy, in the form of heat and light, have been determined, but the methods have not been sufficiently simplified to make them readily applicable in experimenting. Temperatures are still given in arbitrary degrees, and intensity of illumination has no acceptable basis expressible in terms of the fundamental quantities mass, time, and distance, although several methods have been suggested in which the direct, subjective estimate of it by the eye plays no part.

This brings us to a consideration of the great service rendered to scientific investigation by an absolute system of units and measurements. Such systems were instituted by Gauss and Weber between the years 1834 and 1850, and their introduction was especially fruitful in the study of electricity. The mechanic was enabled by that means for the first time to compare the electric forces produced with the mechanical ones employed, and gained thereby for the first time a just estimate of the former. The adoption throughout the scientific world of the centimetre-gramme-second absolute system for all branches of science is by no means the least valuable outcome of the development which electrical science has undergone since 1850, for in the possibility of tracing back all natural phenomena to the three mechanical units of space, mass, and time, science received new evidence for the inherent unity and the mechanical character of all forces of

Nature. Energy as considered in physics, apart from chemistry, has been classified in various forms, viz., energy of motion (translation or rotation), strain, vibration, heat, radiation, electrification, electricity in motion, magnetization, and gravitative separation. Those forms which are represented directly by bodies (whether extended masses or molecules) in motion or deformation, and which do not appeal to our special senses for recognition, constitute mechanical energy. The first two named above are plainly such, and all the others except the last have been shown to be such indirectly; it is generally believed that the last will be found to be reducible to the same form, so that probably all are essentially mechanical, and physicists are hoping to reduce them all to the mechanical as the ultimate form of energy. The importance to the physicist, therefore, of an acquaintance with the principles of mechanics can not be overestimated: without such an acquaintance his efforts to unravel the mysteries of physical science or to gain possession of its secrets will be futile.

FORM AND LIFE.

By M. GEORGES POUCHET.

IN the first glance over Nature, everything living, every plant or animal, and every part of what lives, seems to have a definite shape; and we are naturally led to regard form in organized beings as an essential attribute of life. On the other hand, gases, which spread out into infinity; liquids, molding themselves on the walls of the vessels that stop their flow; rocks, cut into a thousand shapes without ceasing to be the same rock—show us an inorganic world almost wholly freed from the fatality of form. Crystals, indeed, seem to form an exception to this. They also have limited shapes, with contours even much better defined than those of life; but when we bray them in a mortar, they are still always the same body, and the same chemical species, even though they are no longer crystals. A living being, sugar cane or beet root, rasped or reduced to pulp, has no longer anything of itself. It has ceased to be, and no power can, from the pulp, build the organism back into its former shape. But we can reconstruct the crystal, and draw it anew from its dust.

The living being, considered in itself, independently of the being from which it is derived and those which will be derived from it, is, in its way, with some exceptions, a sort of atom, an indivisible whole. Hence that very just denomination of *individual*, to designate the being endowed with life.

What we call species in speaking of plants and animals is

really only the grouping made in our mind of all the living individuals exhibiting the same form, and which we believe to be all united under a common parentage.

Yet form can not serve of itself to characterize life, for there exist other bodies than crystals in the inorganic world which are individuals. The planets and the rings of Saturn will at once occur as examples. We might also range in the same category comets and whirls of smoke, which are likewise individuals, and cease to be by the mere fact of their division or dissociation.

Form is therefore not sufficient to characterize the living individual. Let us see if the general features and external aspect of organized beings will not offer us marks to distinguish them from mineral bodies. The plane faces, the sharp edges, and the definite angles of crystals, and the spherical contours of the heavenly bodies, have been contrasted with the undulating surfaces, the less geometrical and more softly defined profiles of plants and animals. This trait is certainly not destitute of value, and the untrained mind is rarely deceived by it. Sometimes the lapidary, in cutting agate, uncovers delicate arborescent shapes in the transparency of the gem. The illusion is vivid, and one might fancy he had a petrified moss under his eyes. A lens will assure him that there is no vegetable fossil here, and will reveal an assemblage of crystalline needles that have nothing in common with the delicate articulations and waving lines of a genuine moss.

Its particular stamp is so clearly impressed on each living being and on each of its parts, and it is so recognizable that it guides the naturalist with certainty, even when he affirms, from the smallest remnant or weakest impression, the existence on the surface of the globe, in prodigiously distant times, of beings that lived then, and with which he is unacquainted. Some of the organisms have left only traces, and he affirms that life passed there, without knowing whether it was vegetable or animal.

The ancients, although they had not our experience in interpreting the true nature of fossils, never failed to recognize the factory mark which Nature impresses on its works. Science then gave no means of discerning in ammonites the shell of an animal allied to the squids and cuttlefish; but the finders had at least the feeling that these things had lived, and, by analogy, they saw in them the bones of animals preserved in the earth.

Form is not an essential attribute of life. There exist living beings destitute of living form, as there exist chemical substances that do not crystallize. The microscope reveals in stagnant water gelatinous masses that change their form and move incessantly. We see a part of the mass stretch out like a foot advancing. Then the whole being seems to pass into this prolongation, which is proportionately swelled out. Another expansion occurs at an-

other point, and the viscous drop, changing shape continually, seems to flow along slowly. If it meets any vegetable matter, it envelops it, and the stuff suffers a real digestion. The residue is cast out, as it was absorbed, by any point of the surface. We call these beings *amœbas.* They are capable of multiplication by division, and every part of them is susceptible of being indifferently surface or inside, the drawing part or the part drawn, mobile all at once. For the amœba can choose its direction and find more light or more darkness according to what we may call its aspirations, since it acts, definitively, as a living being.

If we open a tan vat in the spring, we shall discover here and there irregular golden-yellow filaments, soft and slimy. We observe them changing their place and flowing like the amœbas. They appear to be seeking one another in the mass of tan, for in the summer, after a shower, they may be seen to join, then rise in the shape of a kind of yellow cake, large and thick as the two hands; the botanists call them *myxomyceta,* or the slimy fungus. Detach a part of this mass, put it on a potsherd, and it will, like the amœba, extend branchy expansions, pass itself upon them, stretch out and return upon itself in changing lumps, to be succeeded soon by new stretchings.

We see in these, beings without form, without organs, composed solely of an opaque substance, and highly colored in the myxomycetes, but transparent in the amœba, a little denser than water, with which it does not mix, a substance that moves and feels—that is, that shares with us the higher attributes of life. The discovery of the amœbas was at first merely a curiosity till Dujardin and Hugo Mohl, almost at the same time, called attention to a substance entering into the composition of infusoria and the cells of plants that had all the characteristics of the substance of the amœbas. Dujardin called it *sarcode;* Hugo Mohl, *protoplasma,* and that name prevailed. The term, imposed as the name of one of the constituent parts of the vegetable cell, has had the singular fortune to become almost synonymous with matter living or that has lived.

This amorphous substance is the basis of the organism. In plants, it is what in some way builds up every cell, as the worm and the mollusk produce the shell and the tube that protect them, or as the caterpillar envelops itself with the cocoon which it draws out from its glands. So the protoplasm molds around itself the walls of the cell in which it is inclosed. But it is always the prime living part, and when it disappears the cellular wall becomes only an inert body. In animals, likewise, the egg, or at least its essential part, the *vitellus,* shows in its almost universal spherical form the protoplasm shaped at first only by the laws of attraction and resistance common to all matter. But when the egg takes life, the

first signs it gives of its activity are movements comparable with those of the amœba. Thus, without effort, we find on different sides life freed from form. We comprehend that it is not essentially and fatally bound to form. A body may be living and still have no definite figure. Here the problem is suggested, whether a liquid, a bodily humor, can be living. Is the blood living, like the substance of the nerves or the flesh of the muscles? It is a deep question and has not yet been answered. At any rate, science has been led for a long time to look for the characteristic of life somewhere else than in form.

The Aristotelians saw a movement in what we call life; and they gave that name to every change of state of natural bodies as well as to their translation proper in space. Aristotle's treatise on the Soul characterizes life by the three facts of its nourishing itself, developing, and perishing. Growth and decline are changes, and consequently movements; and, as we always see them closely connected with the feeding of the plant as well as of the animal, we find the act of feeding definitively at the basis of the movement which is life. Moreover, do we not see during growth the parts of which the creatures are composed changing places relatively to one another? Have we not here a clear, absolute distinction from the increase of mineral bodies?

There are, however, some parts in animals which grow by a simple constant accretion of superadded new particles; such as the shells of mollusks, even when they are covered by the flesh, like cuttlefish bone. But these formations, although derived from the organism, are not themselves living. They bear, if we may say so, the stamp and seal of life so far that we can recognize them as a product of it, but no further; and if they grow, it is as crystals do.

Thomas Aquinas, following Aristotle, gave life the most exact definition that could be made with the knowledge of his time. It is almost as satisfactory for us, for we, too, define life in the same terms. It is a movement, but still not one of the apparent though intimate movements to which the Christian encyclopedist alludes. It is a molecular movement that escapes our eyes, in the interior of the being, and is revealed to our senses only by its results.

The movement that constitutes life is an intimate, profound, invisible, incessant movement, at once of combination and of decomposition. Living matter is incessantly born and incessantly dying, being formed and suffering destruction all at the same time.

All liquid or gaseous bodies coming in contact with a living substance and soluble by it, penetrate it, mingle with it, and then, carried on in the whirl, cease for the most part to be themselves, are transformed, enter into new combinations that did not exist

outside of the being, but which are in their turn destroyed and pass into other conditions unsuitable to life, and in which they are cast out to re-enter the inorganic world, which is enriched through them with ammonia, carbonic acid, and oxygen. We are not acquainted with the nature of this movement; we know only that it exists by comparing what goes in and what goes out, and these with the intermediate term, the living substance itself. We know that it is propagated at the same time in all the tissues and all the organs of the being, offering in each a special modality while retaining always the same fundamental character.

This movement is fundamental to the tissues of the living being, from the most simple of them, like the substance of the bone, to the most complex, like that of the muscles or the brain. It is always in the living being, whether it is growing, thriving, or declining toward death, or is attainted with different passional, morbid conditions that might affect it. It is always present in the infinite variety of physiological acts of which our life is made up and which all inevitably lead to an impending molecular modification: the sensation of the retina disturbed by a light-ray, the contraction of a muscle, and even thought. In connection with the last, the effort has been made to reach by tortuous ways the nature of the chemical reactions that necessarily accompany all brain work. Whether this is reached or not, it is impossible to conceive the operation of the nervous elements otherwise than as a phenomenon of nutrition—that is, as a modification brought about in the molecular movement.

But we are still unable to penetrate and discover the true nature of that inner molecular movement which makes of animated bodies a world apart from the great cosmos. What are the origin and nature of that new energy communicated to inert matter, giving it properties or rather faculties which it had not before, and which are additional to all those with which the chemist and physicist are acquainted? Let us say, further, that they are added to these without contradicting them, as was believed for a long time when a kind of antagonism was supposed between life and the physico-chemical forces. Life is in no way a triumph over these forces, and they always keep their predominance.

Vital movement is, after all, only an episodical modality of the universal faculty which simple and compound chemical bodies have of reacting upon one another. It requires for its manifestation, like every other reaction, definite conditions, confined within narrow limits, of pressure, temperature, and light.

But the thing we are absolutely ignorant of is the real nature of those inner reactions of which we can not in many cases give the rigorous formula and still less define the thermic equivalent; the generic quality, as it were, of those movements, at once special

and infinitely varied, which are going on incessantly in the parts of living bodies. We know that the vital movement in each individual is to come to an end at a given moment—that is death. We have a thousand means of provoking a stoppage of it. We can only propagate it in a certain way when we furnish it, by means of food or generation, with the material substratum necessary for its production and development. We can in like manner divert it and cause it to produce monsters; but we have no power to make it appear where it does not exist.

Vital movement is continuous. It was formerly thought possible to suspend it; that seeds and living beings could die for the moment, and the former keep intact their faculty of germinating, and the latter return to a new existence when placed in favorable conditions. Reviving animals have excited much attention, but little thought has till the present been directed to the supposed suspension of life. In reality, these beings continue to live, but extremely little. The vital movement is not suspended, but is considerably diminished rather than retarded, like the vibration of a sounding cord which loses in intensity till it is no longer heard, while the finger can still feel it tremble. About forty years ago some speculators upon public credulity publicly distributed through all Europe, selling it very dear, a wheat which they said had been taken from a mummy in Egypt, and which when planted gave a prolific return. This was a simple cheat. Yet seeds are known which have retained the germinating faculty a very long time; they really continue to live, carrying within themselves the inner movement which becomes slower every day and ends with extinction. The seed will inevitably die; whether it be after a few years or in a century or two makes little difference—it will die.

Vital movement is then continuous, but with incessant renewals, and it also has a very special character. It is propagated indefinitely, while it continually casts off a part of the materials which it had previously animated. That yellowed wheat which the reaper is going to cut, the stubble of which is destined to cover some cottage, the seed of which seems wholly devoted to the support of the life of men, which has to our view not lived a whole year—that wheat is eternal; it has lived through all the past, and may live through all the future. It has dried, but that is only in appearance. Life has not withdrawn from it. Planted next year, it will project a new head, and so on for thousands of years.

We are accustomed to regard as a living being having a kind of beginning and end the head which issues from the seed in the spring, and which autumn will mature. The conception is wholly arbitrary. We really know of no beginning or end to this head. It is not even an individual in the philosophical sense of

the word; for it is connected by continuity with all the heads of wheat that preceded it and with all those that will follow it. The important part is the seed, or the germ which it includes, continuing itself by a stem and a flower into another seed like it. The root, the straw, the glumes are accessories—all to be abandoned every year by the seed incessantly reviving of itself, which veritably incarnates the species *wheat.*

The molecular movement being at the very basis of life, to what extent does it regulate its manifestations? Does it make its influence felt only to maintain the external form or to exert a certain amount of command upon it? It does command it in effect, and all the external characteristics of the species and the individual appear to us definitely as subordinated to the conditions of their inner chemistry. Chevreul was the first who formulated the principle of the absolute dependence of life on the physico-chemical laws of inert matter. The demonstration of it is furnished in the manure and fertilizers by means of which we succeed in prodigiously modifying the external appearance of the plant, to the point of rendering it almost unrecognizable. This sprout, in a dry, arid soil, is stunted, coriaceous, and hairy; that other one, from the same kind of seed, growing in the shade, on a soil constantly moist, is large, plump with water, soft and smooth. Without more knowledge, we should see in them two distinct species, if all the intermediate terms did not meet here and there on grounds half dry or half shaded, to show that we are simply dealing with two individuals of the same species, the molecular constitution of which is not absolutely identical because of the different conditions in which each one has lived.

It was long thought that the plant could choose by its roots the substances in the earth useful in its support and growth. This is not correct. The root, in contact with the extremely complex bodies which are continually formed and unformed in the soil around it, takes all those which the spongy terminal tissue of each radicle can dissolve. The plant is in this case only a reagent like any other; it is passive, and suffers itself to be penetrated by every substance, useful or injurious, in the quantity in which that substance is susceptible of mingling and combining with its superficial tissues. By virtue of the molecular constitution of the walls of the root, and especially of the extreme cells of their fibers, plants absorb particular mineral principles, and these principles in their turn, drawn into the vital molecular movement, favor it, impede it, or modify it in some way, and at last provoke a perceptible change in the aspect of the plant. This direct, immediate influence of molecular constitution on the forms of living beings appears to be more sharply marked in plants, but that is perhaps

because animals have not been so carefully studied with reference to it. Some practices well known to horticulturists demonstrate with a singular evidence this subordination of extreme characters to the chemical composition of living matter—as in some of the methods by which new varieties and colors are obtained.

With the aid of analysis and the balance, Prof. Armand Gautier exhibits to us these new appearances of plants in relation to the formation of new chemical compounds in them. This has been done under such conditions that it can be said of every animal or vegetable hybrid that it does not represent simply the mingling or the combination of the two forms from which it is derived, but is still more the expression of new molecular combinations giving rise to intermediate chemical combinations. We have a right now to affirm that the blood of the mule, in its intimate composition, differs as much from the blood of the horse as from that of the ass.

It is agreed that the different varieties of the European vine are variations of the same species slowly modified under the influence of man. This almost indefinite variation has not only resulted in advancing florescence and maturity and in differences in the quantities of tannin, sugar, and coloring matter in the fruit and other parts of the plant. Each of these external changes is in some way only the expression without of certain chemical changes. There appear to be as many kinds of coloring matters of seeds as there are varieties of grapes, and so different that some of them are soluble in water and some not; some crystallize, others remain amorphous; some precipitate the salts of lead in blue, and some in green. In a general way it may be affirmed, from M. Gautier's experiments, that each variety of vine has seen arise in it a new chemical species which would not have existed in Nature any more than the form with which it is associated, if man had not intervened. Man, therefore, in creating hybrids, not only makes new forms, but also throws into Nature chemical principles that had no place there.

The possibility of working in some species of animals the remarkable changes which skill has impressed on the plants of our fields and gardens can hardly be doubted. By depriving an animal of some one of the mineral principles that enter into the composition of its tissues, we should in all probability greatly modify its external form.

A single experiment is known to us which has been made in this direction by M. Chabry at the marine laboratory of Concarneau. He selected, as the animal to be experimented upon, the larva of the common sea urchin. It was seen, a few hours after it came out from the egg, as a point moving rapidly in the sea water. Observed under the microscope, it first appeared the shape of a

bell; later, it took a strange shape, which was not inappropriately compared to a lectern. M. Chabry even designated it by the Latin name *pluteus,* which means pulpit. As the time for this change of form approaches, there can be seen appearing in the tissues of the young larva a kind of calcareous needles, called *spicules,* the form and disposition of which are identical in all individuals of the same species. These spicules are composed of the carbonate of lime which the larva finds in the sea water, and which it absorbs as the roots of a plant absorb the potash contained in the soil. This lime traverses the tissues of the larva and collects for a time in them before settling in the half-crystalline figure of the spicules. It may be remarked that although they present a regular arrangement in the larva, the spicules have no relation, at least in the beginning, with the external form or the shape of the organs of the animal.

M. Chabry asked what would happen if he tried by raising the larvæ in water destitute of lime to prevent the formation of the spicules. The experiment was not without difficulties. It was necessary to prepare artificially a limeless sea water. With all the pains M. Chabry could take, in the light of the best analysis, the larvæ perished in the artificial water as soon as they were hatched. He then tried diminishing by degrees the proportion of lime in the natural water. This lime was the sulphate, and the experiment was directed, in order to prevent too radically changing the water, to substituting another base for calcium. Sodium was taken, because, it being already very abundant in the water, the slight addition of it which it would be necessary to make to replace the lime could not have any great influence. The results were very plain. Without any mixture of lime in the water, the just-hatched larvæ were arrested in their development and died in a few hours. If the elimination of calcium is not pushed to its extreme limits, and only a fifteenth part of the already very slight quantity contained in sea water is left, the larvæ will not be for forty hours distinguishable from those which are developed in normal water. At the end of that time the spicules should appear while the larva is assuming the form of the pluteus. But in water containing only a fifteenth of the normal calcium this change is not effected. Twenty hours later, in the sixtieth hour of their lives, the larvæ are still in the same condition, while those in normal water have spicules already branched, and their having taken the form of the pluteus is marked both by their shape and by the division of their intestine into distinct regions. The larvæ deprived of lime first exhibit this modification of the intestine toward the ninetieth hour, but they have no spicules and have not become pluteus. Their external form has therefore been profoundly affected by some change that has been introduced into the inner

composition of the tissues and the humors through the absence of one of their necessary constituents. The disturbance was not sufficient to cause the larvæ to perish or to stop the vital movement, but that had been diverted and had resulted in a new configuration of the living being. We have made a monster by a chemical process. No doubt a certain number of monstrosities besides those resulting from accidents that have occurred in the course of the development will eventually be attributed to a category of special changes like those which M. Chabry provoked.

A recent discovery has further cast a very striking light on that mysterious relation that connects the chemical constitution of beings with their external form. Aside from the serpents, only a few vertebrate animals are known that distill venom. On the other hand, notwithstanding the deep organic differences that remove the fishes from the reptiles, we find a few among them—the conger, the eel, and the sea eel—that have the appearance and almost the form characteristic of snakes. Prof. Mosso has lately shown that the blood of these fishes with the shape of a serpent is poisonous, even very poisonous. Half a thimbleful of eel's blood injected into a dog is enough to cause the animal to fall dead just as if it had been bitten by a rattlesnake. What is the connection between the presence of this poison in the blood of the eel and the shape of its body?

We may summarize in rigorously scientific language what we have just set forth by saying, with Chevreul and Charles Robin, that the form of living beings is a function of their molecular constitution. It is a point to which Darwin and his partisans of the transformist school have not perhaps given sufficient attention. Everybody now accepts these doctrines in their main features, but they have not taken into account, at least not fully, the factor of the influence of the medium. They have overlooked this chemical necessity which is imposed with every change of form or simply of color. We shall know, as M. Gautier has foreshadowed, the limits of the possible variations of an animal species when we learn how far it lends itself to the creation of new organic compounds. Even when there is nothing more than an exaggeration of a group of determined organs, a determining modification must be admitted in the chemistry of the individual. If media have been able to act, as everything indicates, it has been only by slow and progressive modification of the molecular constitution of the being, involving inevitably in its turn the changes of external configuration that determine each animal or vegetable species. The transformists show us with complete assurance vertebrated animals descended from some inferior animal, worm, or mollusk. Which? Here they cease to agree, and every one's preferences are suggested by this or that vague resemblance in

the disposition of the internal organs. But, if this were ever so much greater, there would still remain something to explain and something of importance. This vertebrate has muscles, organs of senses, viscera like the various animals from which it is supposed to have proceeded. But there are, further, in it living substances of a special order, cartilage and bone, which are real chemical species. When, how, and under what circumstances did these substances appear which we find identical as to themselves in all vertebrates which no other existing animals possess? It is not enough to show us this animal type proceeding from that other, that organ developing itself or disappearing or changing place and relations. We want to be told through what internal chemical actions these organic compounds appeared; those clearly defined substances the presence of which establishes an absolute distinction between vertebrate animals and the worms or mollusks from which they are supposed to descend.

Just as the appearance of new chemical compounds hitherto unknown was the necessary condition of the formation of new organic types, so it seems proper to suppose that at the beginning life on our planet appertained only to amorphous masses, which, in a prodigious succession of ages, after incommensurable periods, in consequence of an intimate working in their substance, were succeeded by existences the contours and dimensions of which were gradually and progressively defined. The sense of this necessity, doubtless, haunted M. Haeckel's imagination when he supposed that the *Bathybius* was the primordial jelly whence all living beings were derived.

On the other hand, this idea of a simple beginning of life was too far lost sight of by M. F. A. Pouchet and the later champions of the doctrine of spontaneous generation. It is not shown that the question of heterogeneity, which was so exciting thirty years ago, can ever be answered. In any case, it can not be revived under the form which its latest defenders have given it. Their chief error, from which all the others have been derived, was in wishing to overshoot the mark, in seeking to create at the bottom of their matrass, not substance having life—a bit of sarcode or protoplasm—but a being having a definite form. In the modern idea of the necessities of life, form appears to us as an epiphenomenon resulting from infinitely numerous and infinitely progressive circumstances. To sum it all up, form is pre-eminently a hereditary characteristic. It can exist, we can only comprehend it as slowly acquired by a process of modeling a thousand and a thousand times secular. It was this form, this figure, that the partisans of spontaneous generation thought they brought forth in their apparatus! The objection we raise here, very curiously, was never made to them, and their theory was only ruined by

detail, by the production of facts undermining their experiments, but which did not touch the foundation of their doctrine. No one will ever cause to appear in a vial, by combining all imaginable elements, a microscopic animal or plant, however simple, with a definite configuration, because that requires duration of existence behind it. The problem to be solved is not there. The necessary thing is to create that unknown molecular movement which alone constitutes life and which brings on all the rest.

At the present time chemists seem to be on the point of obtaining by synthesis substances similar to those of which some of the important parts of animals and plants are made; but we must not nourish a chimerical hope too rapidly. There is a chasm between the end almost reached by M. Schützenberger and others, and the creation of the smallest parcel of living matter. One may make albumin like that of an egg, fibrin like that of the blood, but he will still have inert substances, as they are. The white of an egg is not living, although it emanated from a living being, no more than the shell and the greater part of the yolk. It is simply a secretion—an outthrow of the living flesh of the hen—and which acquires from it nothing more than a composition nearly identical with it, and in any case extremely complex. Hence the difficulty of reproducing artificially a similar body by the synthesis of the very numerous chemical elements that compose its delicate structure. Every molecule must be there and in its place. Even when this synthesis has been performed in his retorts, has the chemist produced life? Not at all! He will be like Prometheus in the face of his clay statue; the fire from heaven will be wanting—the living fire. That albumin, that fibrin, the issue of the combination of any number whatever of the different elements that should compose it, remain inert substances.

Yet the thought of producing living matter does not seem entirely hopeless. The conditions have already necessarily been realized on the planet, and perhaps many times. It is not impossible that at the bottom of the ocean or in stagnant waters sarcodic masses are still taking spontaneous birth. We have no evidence of it, but such a phenomenon does not appear liable to the fundamental objection. How shall we surprise this beginning of life? If science shall ever succeed in achieving this great work in its laboratories it will have accomplished the desire of the first man of the Mosaic legend. We shall know what life and death are. The dream of the heterogenists will be realized, and man will indeed have created life.—*Translated for The Popular Science Monthly from the Revue des Deux Mondes.*

ON ACCURACY IN OBSERVATION.*

By H. LITTLEWOOD, F. R. C. S.

THERE are many theories afloat to solve the great question of medical education—what subjects should be taught in the early part of the curriculum, and what left out. I do not think it is quite such a great matter what is taught: how it is taught is of far more importance. For I take it that there is no training which can turn out a medical man who is up to date in every branch of his profession, and very thankful I am that there is no place in the world for such a prodigy. He would be very like a historical character described in one of George Eliot's novels: "The simplest account of him one sees reads like a laudatory epitaph, at the end of which the Greek and Ausonian Muses might be confidently requested to tear their hair, and Nature to desist from any second attempt to combine so many virtues with one set of viscera." To hear some men, and even medical men, talking, one might almost suspect that we had found the realization of such a description. The great aim and object of medical education, and, in fact, of all education, is that it should make you accurate observers; and any plan or scheme of education that has not succeeded in this has been a failure, even if, after years of study, you can write the whole of the letters of the alphabet after your name. You hear people talk of education, and of So-and-so going to this or that school or university, either at home or abroad, *to finish* his education. Never was there a more mistaken notion. The word "education" should almost be used like the word "eternity." It must go on as long as humanity exists. What you should be doing at your school and university is to train yourselves to observe things accurately, so that you may rightly interpret their meaning. Let me tell you it is a very difficult thing to be accurate. You will, I am sure, forgive me for again quoting from George Eliot, but she has so well expressed what I want to say: "Examine your words well, and you will find that, even when you have no motive to be false, it is a very hard thing to say the exact truth even about your own feelings: much harder than saying something fine about them which is not the exact truth." If such is the case, we can not be too laborious and painstaking in order to eliminate error. If your early studies in chemistry, biology, anatomy, physiology, etc., have been rightly conducted, you should have learned to note facts and to make careful observations; and you will find this training invaluable when you begin your hospital work, as also during the remainder of your

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* From an address delivered before the Yorkshire Medical Society, on October 18, 1893.

medical lives; for the whole art and science of medicine must be founded on accurate observation. All careful students of medicine should be good and accurate note-takers; the practice of sketching and making diagrams of the things you are observing is a very valuable one to cultivate. In taking notes on your cases acquire the habit of putting your observations on paper while you have the patient before you; compare the diseased or injured part with the corresponding healthy part; and if both similar parts are affected, you must compare them with what you have learned to consider as a healthy ideal. If records are not made at the time they lose somewhat of their value, even if they are made within a few hours after the appearances observed have been described; but if left days or weeks—and I know this is sometimes the case—the imagination is left to fill in the details; and should they be left for a much longer period, it is perfectly astonishing what may not be described as facts, especially if the writer is anxious to make the accounts read well. I believe this is the reason why there is so much doubt about so-called facts; a good many of them are not facts at all, but merely expressions of a very fertile imagination. There is more truth in some of the stories of the Arabian Nights. A certain part of what has been called the new criticism of some ancient writings and records consists in trying to ascertain how soon after seeing these events did the eyewitness write the records. Of course a good deal of the value of these records depends upon the decision of such a point—how much and how little has the imagination taken part in the evolution of these so-called records of well-authenticated facts? Then, in describing your cases, do not use language that lends itself to exaggeration. Whenever you can put down actual measurements and actual figures it is much better to do so.

According to the statistical tables of some operations and new methods of treatment one finds all the cases, or a large majority of them, classed under the heading of "cured." This is a very unfortunate word, for it appears to have a variety of meanings; and what one person understands as a cure certainly would not come up to the standard of another. I often wonder if the notes of some of the failures have not been lost or if the cases of failure have not been removed, because, for some reason or other, they do not quite come within the category of the title-heading selected for these tables. We do not find many statistical tables of failures. When one reads these accounts one wonders if they were written for the purpose of finding out the truth, or was there some other motive? Macaulay, in his essay on Gladstone on Church and State, has a passage which I think I may aptly quote here: "It seems quite clear that an inquirer who has no wish except to know the truth is more likely to arrive at the truth

than an inquirer who knows that if he decides one way he shall be rewarded, and if he decides another he shall be punished." But as students your first object must be to be accurate. I will give you one or two examples of curious notes that I have seen lately made by some students. I was reading an account of an operation I had performed the day before, and, finding not a single statement in the note was quite accurate, I asked how it was that such an account had been written. The student excused himself by saying that he had not seen the case, but had gathered from another that I had done exactly what he described. In another example, from some notes on two cases of suprapubic lithotomy undertaken on the same day (and these were written by an eyewitness), I was startled to read in both the accounts this passage: "The peritonæum was then opened." I need hardly say that this statement was pure fiction. I quote these examples to show you that I am not exaggerating; I am sorry to say I could multiply them. Of course you will all agree with me that notes of this kind are infinitely worse than no notes.

Now, how is it that it is so difficult to be accurate? I think accuracy means a careful training of all one's faculties, and this is so often neglected. It is so much easier to let other people think for us than it is to think for ourselves. A medical man who has not acquired the faculty of thinking and interpreting for himself has missed his vocation. I have sometimes heard students remarking on the physical signs of a chest, that such and such parts are dull on percussion, or that there was a cardiac murmur heard at a certain part of the chest because Dr. B. had said so, and not because the speaker had appreciated the differences of sound. You must learn to appreciate these things for yourselves by trying to test them by your ideal normal standard; and until you have actually heard, seen, or felt them, these things can not be said to exist as far as you are concerned. The eye only can see what it brings with it the power of seeing. When you first look down a microscope everything looks indistinct, a mass of pretty coloring; then, after training, certain details are observed—nuclei, nucleoli, fibers, cells, etc. After carefully studying the detailed structure of an organ you can recognize it the next time you see it; then, knowing the different elements of which it is composed, you can recognize if it is a specimen of a healthy organ or if the organ is in any way diseased. The trained eye is able to see endless minute differences where the untrained eye discerns nothing. Things look very hazy and indistinct in the first gray of the early morning; every day of your lives adds some new facts, some new observations, and each day brings you nearer the brightening sunshine of a more extended knowledge, until some of you may be fortunate enough to realize the

lofty ideal of Prof. Huxley: "Education promotes morality and refinement by teaching men to discipline themselves, and by leading them to see that the highest, as it is the only permanent, content is to be attained, not by groveling in the rank and steaming valleys of sense, but by continually striving to those high peaks where, resting in eternal calm, reason discovers the undefined bright ideal of the highest good—a cloud by day, a pillar of fire by night." We do not all see the same differentiations of color or appreciate the varieties of taste, smell, or touch, or hear to the same extent the infinite variety of musical expression; and it is only by cultivating our senses that they can be improved. About a year ago, at the Ida Hospital there were some very offensive smells. Everybody thought there must be something wrong with the drains, until the resident, Mr. Wilks, discovered a horribly offensive fungus. I requested him to bring some specimens to the infirmary weekly board meeting, and I was very much interested to hear what the different members would say. The first to examine it said that "it did not smell at all"; the second that "it was not so bad"; but all the other members agreed with me that it was horribly offensive and quite accounted for the bad smells. I mention this as an example of differences of opinion about a fact as to whether something was or was not offensive, and to illustrate that we do not all appreciate sensations to the same extent. You are all of you familiar with the curious phenomenon of color-blindness; but there is a much more common and not so easily detected form of blindness which has received the name of "intellectual blindness." We all suffer from it more or less; some to such an extent as to be almost like unto an ancient description of some heathen gods, "who have eyes and see not, ears and hear not, noses have they and they smell not." You have all of you been struck with the fact that there are certain things we see every day, yet all at once we discover something in them we have never noticed before. I venture to predict that, if I gave all of you a piece of paper and asked you to write down the exact figures as they appear on the face of your watches, not one tenth of you would put them down accurately—i. e., of course if you have not already tried the experiment—and yet all of you have seen your watch faces several hundreds of times. Or, if you like to make the experiment of getting half a dozen eyewitnesses to describe something they have seen, it is more than probable we should find very marked differences in their descriptions. I think you will agree with me that some of the descriptions in the daily papers bear out this contention. You often have your mistakes pointed out to you before you are conscious of their existence. You must have very clear ideas of the anatomy and physiology of a human being in a healthy condition before you can

become accurate observers of disease. This knowledge can only be obtained by diligent work in your dissecting rooms and laboratories; there is no royal road to it. Do not forget that you are all disciples of William Harvey, John Hunter, and Charles Darwin.

To sum up in one short sentence. Your observations will consist in comparing your ideal standard of the normal with any conditions you consider to be aberrations from that type. Then, having made your observations, the next thing you have to learn is to arrange them in their proper proportional perspective and to rightly interpret their true significance. Given certain altered conditions, how have they been produced? What have been their antecedents? Prof. Huxley has called the interpretation of these facts "retrospective prophecy." In his book called Science and Culture there is an interesting address entitled After the Method of Zadig: Retrospective Prophecy as a Function of Science; and as this method is one which you as students will largely adopt I will venture to read to you the story of Zadig. It is very doubtful where this philosopher lived. Babylon claims him; but he appears to have forsaken this city to live on the banks of the Euphrates, where he could be alone with Nature to investigate and unravel her mysteries.

The story is briefly this: The chief eunuch having been sent in search of the queen's dog, which had been lost, met Zadig, who had seen the markings on the sand left by the straying animal, and from this was able to give almost an exact description of its appearance. Later on the grand huntsman came the same way looking for one of the king's horses which had been lost, and Zadig, having noticed the marks on the sand and the disturbances among some trees through which the animal had passed, was able in like manner to describe it. As neither of the animals could be found, Zadig was accused of having stolen them; he was taken prisoner and brought before the court, and sentenced to transportation. No sooner was the sentence passed than the missing animals were found, so the judges had to reverse their sentence, but fined him four hundred ounces of gold for saying he had seen that which he had not seen. After paying the fine he explained to the court how he had been able so exactly to describe the animals; from this his fame spread widely. The king commanded that the gold should be returned to him; this was done, but three hundred and ninety-eight ounces were retained by the court for legal expenses, etc.

You will be saying, But, after all, this method is only applied common sense; but let me tell you that it is a very great advance on certain other methods which have been adopted by the so-called wise men through the ages. It is not so long ago that

witches were burned because the death of some pigs was thought to be due to witchcraft. Nowadays, probably, the cause of death would appear in the death certificate of those pigs as swine fever; and many of the so-called haunted houses, by the method of Zadig, have been proved to be haunted, not by the ghosts of the departed, but by bad drains. Children often adopt, quite unconsciously, the method of Zadig. I had a good illustration of this last Sunday, and I must tell you about it. Talking to a blind child in the children's ward, I asked her if she knew who I was. She said at once, "Yes, the doctor." I asked her how she knew that. She answered again, "Oh, nurse always says 'Hush' when the doctors come into the wards."

Now, gentlemen, if you really enter into the true spirit of medical work, you will very soon train yourselves to be accurate observers, and from observing human beings you will soon be tempted to investigate and delight in other natural phenomena, to find out your own proper place in this great cosmic system, of which you are only a unit or microcosm. There is no doubt that a true student of Nature has provided himself with endless sources of amusement and happiness. Some of you may remember the lines of Longfellow on the fiftieth birthday of the great naturalist Agassiz:

"And Nature, the old nurse, took
The child upon her knee,
Saying, 'Here is a story-book
Thy Father has written for thee.'

"And he wandered away and away,
With Nature, the dear old nurse,
Who sang to him night and day
The rhymes of the universe.

"And whenever the way seemed long,
Or his heart began to fail,
She would sing a more wonderful song,
Or tell a more marvelous tale."

And this is the heritage of all honest students of medicine who have built up their life's work on accurate observation.

The largest diamond in the world, the Excelsior, was discovered on the 30th of June, 1893, in the mines of Jagersfontein, Cape Colony, by Edward Jorgansen, inspector. It is a stone of the first water, valued at about five million dollars. It was carried to the Cape under the special convoy of a squadron of lancers, and shipped on a gunboat to London, where it was deposited in the Bank of England. It weighs nine hundred and seventy-one carats and three quarters, or two hundred and five grammes and a half.

THE PHOTOGRAPHY OF COLORS.

By M. LAZARE WEILLER.

IT is difficult to give a simple explanation of color. Physicists declare that it is the result of a vibratory movement; and metaphysicians who listen to them pretend to comprehend this. Although it is not clear, this definition is nevertheless the only one it is possible to give. There exists a vibratory movement which is translated into heat, light, and electricity. There are possibly also movements that determine the various psychological phenomena—other vibrations no less confused, no less vague, no less mysterious to our minds than the physical vibrations.

Many persons will be surprised when they are told that M. Lippmann, the discoverer of photography in colors, was never engaged in photography. He discovered in the play of luminous vibrations what he was trying to define in the theory of sonorous vibrations. Being charged with the exposition in his lectures at the Sorbonne of the principles of acoustic phenomena, he sought especially to demonstrate to his students that the pitch of the sound given out by an organ pipe depended on its length and not upon the particular metal of which it was constructed. He was at once struck with the results that might be drawn from this phenomenon; he asked if it would not be possible to transport into the domain of light the curious property that seemed to be involved in that of sonorous vibrations. This conception, in its elegant simplicity, might be said to be a conception of genius. There was nothing in it like the attempts that were made earlier in the century to fix colors photographically. The first experiment in this direction was made in 1810 by Prof. Seebeck, at Jena. He tried to impress the colors of the solar spectrum on a paper covered with a film of chloride of silver. His experiments, though not successful, were much talked about. They were taken up again in earnest in 1841 by Sir John Herschel. Failing with chloride-of-silver paper, he tried bromide and iodide of silver, and natural products, such as guaiacum root. He succeeded by some of these processes in temporarily fixing a few colors on sensitive papers. Such results were encouraging. We were then at the beginning of photography. But these successes were soon surpassed by the experiments of Edmond Becquerel, who succeeded, in 1848, in obtaining upon a silver plate covered with a film of violet subchloride of silver the impression of all the colors of the solar spectrum. Unfortunately, the colors stored up in this manner vanished as soon as the plate was exposed to the light. All attempts to preserve them by means of a fixing bath failed. At every effort the color disappeared. The impression of the spectrum colors by the

Becquerel process lost most of its value by its instability. The science and experimental skill of the celebrated physicist could not overcome this obstacle, on which all who tried to accomplish photochromy by the method of direct impression were successively wrecked.

The chemists Niepce de Saint-Victor, 1851 to 1866, Testud de Beauregard, in 1855, and Poitevin, in 1865, tried to secure the colors by means of chemical substances, but were never able to fix their proofs, or to keep them perfect in the presence of light. After the chemists came the photographers; after the photographers, the men with empirical methods. Then came incomplete geniuses, like Charles Cros, reproducing the colors by superposed prints, without using a direct method, or any effective one. Yet Cros was wonderfully endowed with inventive genius. He had notions about everything. He was one of the first persons, if not the first, to dream of phonography. He occupied himself with the transmission of images to a distance. Occasionally he satisfied himself also with inventing things of a simpler and more positive character, such as his famous paste, a little microscopic box of which would afford ink enough for a whole lyceum for an entire year.

What no one could obtain by any chemical method, M. Lippmann has realized from the theory of vibratory motions. In the soap bubbles, with which every one is familiar, colors of rare brilliancy detach themselves from the thickness of the liquid films, which are themselves colorless. Whenever a transparent body is drawn out into a very thin film it appears with iridescent hues, although it may be made of a colorless substance. The coloration arises from the fact that the light reflected from the two faces of the film has not passed over the same distance. In other words, the light plays by its reflection upon the two planes that bound the film. The result is that the light-rays cross each other and give rise to a phenomenon which is called interference. On closely examining the brilliant tints of the soap bubbles we easily recognize the different colors of the spectrum.

Newton first discovered the causes of coloration, and, to render them more tangible, he devised the experiment of "Newton's colored rings." On an absolutely plane glass he fixed, by its spherical face and without fastening it in any other way, a convex lens; the lens, consequently, did not touch the glass except at one point, all the other points remaining separated from it by sections of air which grew thicker as they were farther removed from the point of contact. When this apparatus is illuminated by a monochromatic light, such as the yellow light given by a lamp burning salted alcohol, there is at once remarked a central black spot on the glass, surrounded by concentric rings alter-

nately bright and dark. These rings are not equally distant from one another; they center at the point of contact of the two glasses. By employing simple lights of different natures we can see the diameters of the rings increase or diminish according to the different wave-lengths of the lights used. It appears, therefore, from this experiment that if we illuminate the glass with white light we shall have the superposition of the effects obtained with different simple lights. In such case the colors can not coincide, and then, instead of having a system of alternately dark and light rings, we shall have rings iridescent with all the colors of the rainbow; and this is precisely what is produced in the soap bubble. The important fact in the phenomenon is that the color varies according to the thickness of the film. In this experiment we are dealing with natural colors, produced without the intervention of any chemical action, but simply by a series of luminous phenomena which we shall shortly explain. M. Lippmann's invention rests upon this principle.

If you blow out a soap bubble it reflects violet as it issues from the pipe; then, becoming larger—that is, the film becoming thinner—it reflects blue, then green, yellow, and finally, when the film has reached its thinnest, red. In this experiment we can perceive what is the real origin of colors. They are only the successive notes of the luminous gamut, as musical notes are formed by the gamut of the scale of sounds. Newton arbitrarily counted seven colors in the spectrum, so that he might make it display as many colors as there are principal notes in the musical scale.

Like sound, light is propagated by undulations through space. This transmission of vibratory motion is carried on with great swiftness, passing through the distance from the sun to the earth in eight minutes. Aside from the difference in velocity, light-waves are like sound-waves. The simple colors are for light what musical notes are for sound. In this way Fresnel, in his theory of undulations, explains the difference in the coloring of the different parts of the spectrum.

Every sound is caused by a vibrating body engendering waves which reach our ear and produce the sonorous sensation in it. But all sounds are not identical. Every one can distinguish an acute note from a grave note. In studying the characters of acuteness and gravity of sound, the conclusion has been reached from experiment that the sounds emitted by a vibrating body are higher the more rapid the vibrations, or the more there are of them in the same time. Each length of wave corresponds to each sound peculiar to it, and is in inverse proportion to the number of vibrations. Since the acute sounds result from the more numerous waves, their waves are shorter and closer than

those of the grave sounds; for they all have the same velocity of progress, and reach us in the same time. The melody and harmony are heard simultaneously, whatever the distance of the orchestra. The exact sensation of the piece played is felt on every side—a thing which could not take place if the high tones of the violins and flutes were transmitted more rapidly than the grave sounds of the violoncellos and contrabasses. It being thus possible to assimilate simple sounds with simple colors, we have to suppose that the number of vibrations determines the color. A luminous point produces, to emit the various colors: red, 497; orange, 528; yellow, 529; green, 601; blue, 648; indigo, 686; and violet, 728 trillion vibrations per second. Each color corresponds with a luminous film of variable thickness. The thicknesses of the several films representing the simple colors—or, what are the same, the wave-lengths of these colors—are: red, 620; orange, 583; yellow, 551; green, 512; blue, 475; indigo, 449; violet, 423 millionths of a millimetre. Red, we thus see, corresponds to the grave notes and violet to the acute notes of the musical scale. To obtain an idea of the thickness of the films corresponding to the different colors, we might take as a standard for comparison a sheet of common paper, which is about a tenth of a millimetre thick. Two hundred and fifty thicknesses of the violet film would have to be laid upon one another to produce this thickness, and one hundred and sixty of the red.

In order to explain the cause of the complex colors of natural objects we may again have recourse to the properties of vibrating motions, which, like those of the phenomena of sound, can be placed one upon another. Thus, when a cord is stretched over a sonorous box, like the string of a violoncello, we can make it all vibrate; its ends will be motionless, while the middle will vibrate with the maximum amplitude. The motionless extremities are called nodes, and the middle is a belly. We can also draw the bow across this cord in such a manner that, while vibrating as a whole, the two halves of the cord will each vibrate on its own account, following a law of individual vibration. Under these conditions a superposition of two vibratory movements is realized—that of the whole cord and that of the two halves vibrating separately. There results a complex sound formed of the fundamental sound and the superposed harmonic. It is this superposition that gives to the ear the sensation of the *timbre* of different sounds; the phonograph, with which everybody is acquainted, is based on this principle. The vibrations of a single membrane can reproduce several superposed vibratory movements, and thus register human speech.

Most of the complex colors, such as rose, maroon, or the various tints of green, can be formed in the same manner. They

may result from the superposition of several simple vibrating motions. In general, the coloring of bodies results from the diffusion of the light-rays which illuminate them. The bodies absorb a part of the rays and reflect others. The mingling of the reflected rays produces on the eye the impression of a definite tint. A cloth appears red to us because it reflects chiefly the red light and absorbs all the other colors. If it reflects all the solar rays as they are, it appears white to us; if, instead of reflecting them, it absorbs them, it appears black.

The origin of colors, therefore, we see, depends upon a physical or mechanical and not on a chemical cause. The white light which comprises them all is only the resultant of the infinity of the colors that exist and succeed one another in gradation from the red to the violet. This may be easily perceived by letting a ray of sunlight pass through a crystal cut in facets.

To comprehend fully the direction of M. Lippmann's thoughts before hitting on the photography of colors by the application of the theory of vibratory motions, we must say a little more concerning the phenomena of interference. When two sound-waves meet, there occurs, according to certain specific conditions, either an amplification of the sound by their combination or a destruction of it by their collision. The principle of the interference of sound was demonstrated by Colonel Napoleon Savart in 1839, by an experiment which is not so well known as it should be. This sagacious officer placed in front of the principal wall of the citadel in which he was garrisoned a bell which he rung by striking it with a hammer. The bell thus became the center of a direct wave which was propagated to the wall of the citadel and reflected from it. In other words, the action of the sound was brought to bear upon the wall, which sent it back to the starting point and thus could give rise to the phenomenon of interference. Some among the soldiers stationed along the line between the bell and the wall observed a distinct re-enforcement of the sound; while others, placed exactly at the points of interference, heard nothing.

What passed in Colonel Savart's experiments is reproduced in the same manner with light-vibrations. Just as sound added to sound may produce either silence or amplification of the sound, so light added to light may produce darkness or amplification of the luminous effect. When direct light falls upon a mirror, it meets on the way the light that was previously reflected, and wherever the vibrations agree in direction the brightness is increased, whereas it is extinguished wherever they are opposed to one another. The space in front of the mirror will therefore be divided into successive sections or stratifications. In some, the light will be of its highest brightness; in others, on the other hand, there will be complete darkness. It can easily be deter-

mined by calculation that the distance between the sections is about one four-thousandth of a millimetre; and it is hence conceivable that, the naked eye not being able to take in such small intervals, the sensation is one of a uniform light. But while the naked eye is impotent, the photographic plate is not. So M. Lippmann thought, when he conceived the idea of utilizing the phenomenon of interference to produce, not in the open air, but on the sensitive photographic plate, the stratifications formed alternately by the luminous and dark lines. By this process the luminous impression of the object photographed will appear only on the sections where the light is bright, while no action will take place in the dark strata.

If, then, we seek to reproduce photographically a body of many colors, each of these colors will find in the thin sections determined by these stratifications the place corresponding to the thickness of each of them. Red will find sections of six hundred and twenty millionths of a millimetre, and violet sections of four hundred and twenty-three millionths of a millimetre, to correspond to the thickness of the luminous stratum producing these colors. So with all the other simple colors, and consequently with the constituent parts of the complex colors. In developing the sensitive plate thus impressed, its thickness will be formed of a series of leaves of photographic silver, separated from one another by distances infinitely small and differing exactly according to the color which has impressed the plate placed behind the objective. We understand, then, that those leaves constitute precisely the organ of reproduction of colors, without which they would have to be colored by themselves. In practical operation it is necessary to prevent any object in the photographic stratum from hindering the fixation or accumulation of the colors in these virtual sections, which are to produce the colors by reflection as the liquid films of the child's soap bubble produce them.

It is necessary, therefore, before everything else, to exclude the ordinary bromide-gelatin or chloride-gelatin plates of commerce, the sensitive coating of which is the result of an emulsion. When examined with the microscope, this washing usually exhibits a very coarse grain derived from solid particles of perceptible matter, which are of considerable dimensions in proportion to the wave-length of a color-stratum. They obstruct that stratum completely, deform its reflecting planes, and prevent all communication of chromatic phenomena. These plates could no more produce the thin strata corresponding to the colors to be photographed than a stone sixteen feet thick can be worked into a wall of three feet. The plates of commerce are, besides, usually opaque and can not be traversed by the direct wave and the reflection wave which are to produce the phenomenon of in-

terference. Sensitive collodion or albumen plates, which have the advantage of being continuous and transparent, are preferable. This choice of processes in sensitizing is, however, not absolute. The pre-eminently important point is that the sensitive plates have no grains, or that the grains be of negligible size—that is, of dimensions inferior to half the length of wave that corresponds to the color.

Without going into operative details we can easily represent to ourselves the process employed by the inventor of the photography of colors to render his invention practicable. The reflecting face of a plane metallic mirror is covered by the usual process of sensitizing with an impressionable stratum of albumen or collodion and chloride or bromide of silver. If a light-ray of any simple color is made to act upon this, it occupying, consequently, a determined place in the gamut of simple colors, there results that the incident rays will traverse the sensitive and transparent stratum, will be reflected on the polished surface, will return backward, and will meet on their return the rays that are coming. There will then be formed two luminous waves—a direct wave and a reflected wave—and these, meeting, will produce interferences. We shall see that what is created in the projection of these luminous rays is only the repetition of what was produced in the experiments of Colonel Savart by the projection of the sonorous vibrations on a wall.

In the photography of colors the space in front of the mirror is filled with parallel planes alternately bright and dark, in such a way that every two of the bright planes are separated from one another by a distance equal to half a wave-length—that is, to the four-thousandth part of a millimetre. There results from this the creation of a large number of these planes in the thickness of the sensitive stratum. In short, this sensitive coating, already very thin, is divided, as the sheet of paper we have mentioned would be, into a number of layers infinitely thinner.

Only the brightest planes could impress the sensitive layer, and in the course of photographic development this impression will be revealed in a black color, while the sections corresponding to the dark planes will not be impressed. If, then, employing the process of ordinary photography, we dip the developed plate into hyposulphite of soda, all the matter sensitive to light and not changed will be dissolved in it, and there will persist on the plate only the infinitely thin sections of reduced silver, and those at the points where the bright planes had fixed themselves. Therefore, the whole thickness of the photographic stratum will be divided into sections by planes of metallic silver parallel to one another and separated by a distance equal to half a wave-length of the simple color which has impressed the plate. These planes,

then, constitute, in pairs, a thin film the thickness of which is precisely that indicated by Newton's theory of the rings; and thus, according to that law, of which we cite the text, the rays reflected upon these two films give, by interference with one another, the sensation of the corresponding color. Furthermore, each color produces in the plate a similar system of parallel planes, the coexistence of which explains the photographic reproduction of the compound colors. The whole secret of the photography of colors lies in the enunciation of this principle.

On observing the reflection of the plate fixed and dried by the process which we have indicated, we shall discover upon it the direct reproduction of all the colors which have been presented before it. The time of exposure plays an important part in the practical execution of the experiment.

The beginnings of the experiments were very laborious. The first effort was to photograph a spectrum, in which the red was extremely inconvenient. The chemical activity of the rays of this color is very slow. They impress the plates so weakly as to permit photographers to use red light without danger while developing their gelatinized bromide-of-silver glasses. Even those least familiar with photography know that red objects are reproduced in black on the positives, and that means that they have not impressed the negative plates, however sensitive. While the red shows itself very slowly on the sensitive plate, the blue and the violet act upon it with great energy, and completely polarize it if the exposure is allowed to continue during the time required to secure the impression of the red. Means, therefore, had to be found to let the exposure to the red be continued for a long time, to the green for a little less long, and to the blue and the violet for a very short time. It is not hard to conceive the trouble which these difficulties, all material, caused at the beginning of the experiments. In fact, they were susceptible of barring the way to every new tentative in the art of practically photographing colors.

How should one proceed in photographing a human being or a landscape? A posing before the objective as many times as there were colors could not be thought of. It would, besides, be necessary to fix the person in the same place, to make him resume the same attitudes—conditions which would make the faithful reproduction of his image impossible. The assistance of a practical photographer became necessary in this emergency.

M. Attout-Tailfer discovered that on plunging an ordinary plate into cyanine, its sensitiveness increased for the red and diminished for the violet, in such a way that by successive applications it was possible to equalize the sensitiveness of the plate for the different regions of the spectrum, and therefore for the dif-

ferent simple or complex colors. This is what is called isochromatism.

By the aid of these improvements M. Lippmann has succeeded in fixing on his plates images of marvelous beauty. The colors have an inconceivable brightness and delicacy of shading. They have nothing in common with painted copies of photographs, which simply enhance the photographic images with coloring. The photographic proofs obtained by M. Lippmann have a strength of coloring and a richness of tone which no water-color picture has ever attained. This is because, in his photography, the registration of the color is combined with the accumulation of all the colored rays.

It is not necessary to say that the learned professor in the Sorbonne has not sought to draw an industrial profit from his invention. It is free to all who may hereafter wish to direct their investigations that way. There remains much still to be done before all the improvements can be given to science. The problem now is to advance from the fixation of the colors on the sensitive plates to their reproduction on paper. Theory permits the prediction that regular reflection by a metallic mirror may be replaced before long by the diffusion of light over a dead surface. It is, then, permissible to hope, without contradiction of the theory of interferences, that the multiplication of proofs by simple printing on paper is only a matter of time. It is easy to understand how much the arts and science are interested in the progress of the photography of colors.

While the pigmentary colors used by painters are made of substances which light may change in the long run, interference colors, which are produced by the vibratory movement alone, depend solely on the physical and mechanical conditions of the experiment, and are not subject to alteration by time. Photography of colors will permit the faithful reproduction of the pictures of the masters, and will also assure the reproduction of meteorological phenomena which may be of considerable importance in future studies of astronomical science.—*Translated for The Popular Science Monthly from the Revue des Deux Mondes.*

A PRACTICAL course of instruction in psycho-physiology was given in University College, London, during the Easter term, by Dr. L. E. Hill. The plan of the course was to take the student methodically over the several senses, and familiarize him with the methods by which the new branch of science known as physiological psychology or psycho-physics determines the precise manner in which sensation varies, both quantitatively and qualitatively, with variations of the stimulus, of the particular portion of the sensitive surface stimulated, etc. The Athenæum acknowledges the backwardness of England as compared with the United States and Germany in the systematic laboratory instruction of students in this subject.

SKETCH OF WILLIAM MATTIEU WILLIAMS.

WHILE the characterization by Mr. Thomas Laurie of W. Mattieu Williams as having been "the first who swept aside the veil that had been hung up between scientific workers and the toiling millions" can hardly be verified, it is an indisputable fact that he was eminently successful in presenting scientific truths in a form acceptable to the common people and adapted to awaken their interest; and his presentations rarely failed to suggest further thought on the subject to which they related.

Mr. Williams was born in London, February 6, 1820, and died in London, of cerebral apoplexy, November 28, 1892. He was taught in boyhood, at three schools of the kind that then flourished, a little arithmetic, grammar, geography, and Latin, but no science. His experiences even thus early set his mind in the train which led him to the adoption of those views on education which he advocated and on which he acted later in life. When fourteen years old he was apprenticed to Mr. Thomas, mathematical and optical instrument maker at Lambeth, where he gained a practical skill and scientific knowledge which he was able to turn to good purpose in the several courses of scientific lectures which formed part of the work of his mature life. Although he had to work from seven o'clock in the morning till eight o'clock at night, he continued to attend the night classes of the London Mechanics' Institution, Southampton Buildings, now the Birkbeck Institution; and during the whole term of his apprenticeship he attended the biweekly lectures which were given by eminent men of the time in their several specialties, and the classes in mathematics, chemistry, natural philosophy, French, German, and phrenology, and took part in the exercises and discussions of the literary societies. The programmes of those societies during the period of his attendance upon them afford as among the subjects of papers contributed by him the Relative Character of the French and English; Constantinople and the Turks; Dreaming, Phrenologically Considered; the Expediency of Railways becoming National Property; the National Characteristics of the French; Direct and Indirect Taxation; the Propriety of Discussing Political Questions at Mechanics' Institutions; and topics related to psychology and phrenology. On coming of age he obtained possession by inheritance of a small sum of money, by the aid of which he studied chemistry at the University of Edinburgh and made a pedestrian tour of two years in Europe. He spent much of the time in Switzerland, Italy, Greece, and Turkey; and, becoming acquainted with the Turk in the last country, found him a better man than he was generally regarded as being, and a person of

better possibilities. After his return from the Continent he was elected a member of the Committee of Management of the London Mechanics' Institution. He opened rooms for carrying on commercially the business of an electrician, an electrical instrument maker, and electrotyper, intending at the same time to deliver lectures on science and travel. But as his friend Mr. John Angell remarks, in a memoir prefixed to his Vindication of Phrenology, "his enthusiastic love of science and general research was destined to become a foe to the habits and forms of attention required in successful commercial business. Many a time friends calling on him late in the evening found him so thoroughly absorbed in pursuing the theory of some practical problem he had succeeded in working out that he had forgotten, meantime, that he had taken neither food nor refreshment since his morning breakfast." He was frequently called on to lecture at institutions at a distance, when he would be absent for days at a time, chiefly on subjects connected with his European tour, among which a favorite course with him was one of six lectures on Switzerland, its social and historical aspects, physical geography, geology, and glacier formations.

About the year 1846 Mr. William Ellis made an offer of one thousand pounds sterling toward establishing a school, to be called the Birkbeck School, on the premises of the London Mechanics' Institution, in which, besides the principles of the natural sciences, the principles of social well-being, or of social and political economy, should be regularly taught. The Committee of Management of the institution were unfavorable to this plan, and ignored it in their report; whereupon a bitter controversy ensued, in which Mr. Williams was active in opposing the course of the committee and insisting on giving a hearing to Mr. Ellis's proposition. Finally, the offer was accepted over the heads of the managing committee, the project was put under the care of a special committee, and the first Birkbeck School was established July 17, 1848, with Mr. John Rüntze as head master. Many years later Mr. Williams met one of his strongest opponents in that controversy, who confessed to him: "We all thought you and your party were wrong; now I know that your party was right and we were wrong."

The Birkbeck Institution was successful from the first, and attracted the attention of George Combe, a man distinguished for his advocacy of schemes for bettering the condition of man, and who had become acquainted with Mr. Williams while he was studying in Edinburgh. He determined, with the aid of money which Mr. Ellis should furnish, to establish a similar secular school in Edinburgh, in which phrenology should be taught in addition to the other branches. The problem of finding a com-

petent and suitable teacher for such an institution presented itself and might have occasioned considerable difficulty, had it not been solved by Mr. Williams offering to undertake the headmastership. It was therefore called the Williams Secular School, and was opened in the Trades' Hall, December 4, 1848. It increased rapidly, and was soon removed to the larger premises which had been occupied by Dr. R. Knox's anatomical school, where it continued "doing invaluable model-work" until Mr. Williams was called, in 1854, to take charge of the Birmingham and Midland Institute.

This institution was projected by a few leading men in Birmingham, and was incorporated by an act of Parliament of July, 1854. Mr. Williams was invited by the Council, on the recommendation of Mr. Lionel Playfair, now Lord Playfair, to become master of the science classes. He gave an introductory lecture, August 17th, which at once aroused interest, and was commended by the press as the work of "a man of no ordinary ability." In this lecture, Mr. C. J. Woodward says, in his account of the institute, "Mr. Williams pleaded for the application of science to industry, and pointed out the important future to the workman who became a scientific man. The classes first opened at the institute were in physics, chemistry, and physiology; but the curriculum soon extended, and an important novel feature in popular education was introduced by Mr. Williams in what were so well known in the town as the 'Institute Penny Lectures.' The first of the series was delivered in the early part of 1856, and attracted large audiences. The first bench was occupied by factory boys immediately the doors opened, and, as intended, many who had their interest in science aroused for the first time were led to undertake the more serious and systematic courses provided at the institute. The idea of penny lectures led, subsequently, to the establishment of penny classes and penny readings, and did much in the direction of popular education."

Mr. Williams was an active citizen in Birmingham, and forward in every scheme for improvement and enlightenment. He was earnest in promoting the purchase of Asten Hall; wrote articles in the Journal urging a more liberal policy on the part of the Town Council, especially in measures for the improvement of the public health; was a leader in discussions concerning education, and advocated the introduction of object lessons and practical illustrations in teaching. He began his career as an author in Birmingham; contributed frequently to the Birmingham Journal; published a pamphlet on The Intellectual Destiny of the Workingman, in which he advocated manual occupations; contributed to the Chemical Society a paper describing An Apparatus for Collecting Gases over Water or Mercury; and, having made

a pedestrian tour through Norway, published his book Through Norway with a Knapsack.

While living here he became unwittingly connected with the Orsini plot for assassinating Louis Napoleon with bombs, which resulted in the destructive attempt of January 14, 1858. He was introduced to Orsini, whom he describes as "a highly educated, refined, and courteous Italian gentleman," in the fall of 1857, and having lived in Italy and witnessed the abuses of the despotisms with which the country was then saddled, "heartily sympathized with his patriotic yearnings for the liberation of his country." Orsini represented to him that the patriots were preparing for a great effort to drive out the foreign intruders, both Austrian and French, but that the watch upon them was so close that they could not introduce or hold ordinary arms. He had therefore invented a new form of stellar gas burner which could easily be converted into a bomb and used as a hand grenade. The gas-burner shells were, however, too small for a charge of ordinary gunpowder to produce effective explosion. Mr. Williams therefore suggested fulminate of mercury in lieu of the powder, and taught Orsini and Pieri how to make it themselves. They also learned how to make fulminate of silver and some other detonating compounds. Orsini, in his final confession, said that the English chemist (Mr. Williams) who taught him how to make the fulminate had no knowledge of its intended purpose. This assurance was accepted by Napoleon and the French police, who gave Mr. Williams no further trouble than that of a few days' secret watching of his movements in Birmingham, which was so delicately conducted that he only discovered it accidentally. Mr. Williams's sympathies with the Continental peoples who were oppressed by foreign despotisms were very strong, and he sometimes expressed them vehemently in his lectures, when he would denounce the Hapsburgs and hold up the Swiss as a pattern people.

Mr. Williams devoted considerable attention, toward the last of his residence at Birmingham, to the chemistry and manufacture of paraffin oil, for which he had patented a process of distillation from shale. Having been appointed manager of the Leeswood Oil Company, whose works were at Caergwile, near Wrexham, Wales, he left Birmingham in 1863, carrying with him a testimonial presented to him by students and friends of the institute. The oil-distilling process was worked with complete success, but without profit; for the product of the newly discovered oil wells of Pennsylvania came into the market at the time and destroyed the sales. Mr. G. Combe Williams writes that "during this part of his career his foresight and influence over the working class, for whose social and intellectual advancement he had devoted so much time and energy, were clearly demonstrated, for

while strikes and labor riots were going on in the surrounding works, his men worked on, having heard the facts of the case from him, and while the other oil-masters were almost without workmen during the agricultural harvest season, his personal influence was enough to keep his men at their work."

After the oil-distilling enterprise had failed, Mr. Williams went to Sheffield as chemist to the Atlas Iron Works. He conducted investigations on the manufacture of iron and steel, the effects of impurities in the same, etc., the accounts of which are fully reported in his book on the Manufacture of Iron and Steel. At Sheffield he wrote and published his book on the Fuel of the Sun, in which he assumed the existence of a universal atmosphere, upon the amount of which the planets can condense about their surfaces the densities of the planetary atmospheres depend. His speculations have not been adopted by astronomers; but the book is said to have received some curious criticisms, and contradictory—from the mathematicians, who said that "the mathematical part of the theory was correct, but there must be something wrong with the chemistry"; and from the chemists, who said that "the chemistry was all right, but there must be something wrong with the mathematics."

In 1870 Mr. Williams moved to London, where he engaged in lecturing at schools. In 1876 he gave what he called an object lesson in geography, when he took his pupils through Norway. An account of this journey is given in his book Through Norway with Ladies. He afterward gave up teaching at schools and devoted his time chiefly to scientific writing, contributing Science Notes to the Gentleman's Magazine, and papers and paragraphs to Science Gossip, Knowledge, Iron, and other periodicals. The more valuable series of these articles were collected and published in the Chemistry of Cooking (published in The Popular Science Monthly and by D. Appleton & Co.); Science in Short Chapters; A Simple Treatise on Heat; the History of the Manufacture of Iron and Steel; the Philosophy of Clothing, and Shorthand for Everybody. His uncle and adoptive father, Zachariah Watkins, by whom he had been helped in youth, to whom he dedicated The Fuel of the Sun, and with whom he dined every Saturday for twenty years, dying in 1889, left him an income that assured a comfortable support, and, as he wrote to Dr. Taylor, editor of Hardwicke's Science Gossip, he was able to begin his life work at the age of sixty-nine. This life work was A Vindication of Phrenology, on which he had been engaged, collecting material, writing, and revising, for fifty years. It was left fairly completed, and is to be published by a London house.

CORRESPONDENCE.

"WEISMANN'S CONCESSIONS."

Editor Popular Science Monthly:

Dear Sir: In your issue of this month is an article by Prof. Lester F. Ward entitled Weismann's Concessions. In this Prof. Ward endeavors to show that Prof. Weismann has virtually acknowledged his own hypothesis on the inheritance of acquired characters to be untenable. But Prof. Ward's reasoning is vitiated by a thread of error that runs through the whole article, viz., the assumption that, in showing that Weismann concedes modification of the germ-plasm by agencies outside itself, with consequent variety in inheritance, he has shown that Weismann concedes the "inheritance of acquired characters" in the sense in which this expression is used by Weismann, Romanes, Lankester, and most other biologists of note. By the expression "inheritance of acquired characters," as used by Weismann and Romanes, is meant the acquirement *de novo* of characters by the somatoplasm of an individual (not characters that the somatoplasm has acquired in consequence of a modification of the germ-plasm) which, in some way, so modify that individual's germ-plasm that its descendants inherit the characters that it originally acquired. This is obviously very different from a modification of the germ-plasm by agencies external to it, that causes the development of new characters in the individuals developed from this germ-plasm and in their descendants. This last is *not* inconsistent with Weismann's theory of the continuity of the germ-plasm, while the "inheritance of acquired characters" (in the sense used by Weismann) is. Prof. Ward also speaks of the Lamarckian law as if he thought what is generally meant by "Lamarckianism" was different from "inheritance of acquired characters" (in Weismann's sense). He makes another obvious mistake where he criticises Weismann's statement on the inheritance of syphilis, and, if my memory serves me, he makes a great deal more out of his quotation from Romanes than Prof. Romanes ever meant, or the context of the words quoted justifies.

Weismann, while one of the clearest reasoners among biologists, is at times a little hard to understand on account of his style, and I think if Prof. Ward will reread his works he will see that he has not done Prof. Weismann justice.

I do not mean to pose as a supporter of all Weismann's views, but he seems to me to have a clearer conception of the problem of inheritance of acquired characters and of the nature of the proof necessary to solve it than almost any other man. At the same time there is hardly an author who is more misquoted and misrepresented—he is one of Darwin's chief rivals in this respect.

Yours very truly, F. R. Welsh.

328 Chestnut Street, Philadelphia, *June* 9, 1894.

EDITOR'S TABLE.

MAN AND WOMAN.

When men and women come to saying ungracious things of one another in a kind of hostile rivalry, the situation is not pleasant, and bodes no good to the coming generation. The evil may be a limited one, yet it is, as far as it exists, a real one, and is already embittering and unsettling a good many lives. Well would it be, therefore, if some one could come forward with an eirenicon that would still the unnatural jarring which is a decided feature of to-day's civilization.

It is the women to-day who are in the main on the aggressive. In fiction and essay they are employing their new-found intellectual powers in demonstrating how poor a creature is man. According to some, it would appear as if man had been the great imposture of the ages, and that a certain instinct of preservation had led him to deny culture to woman, lest he should be found out, and the bubble of his reputation eternally collapse. One recent writer, who, however, assumes a man's name, has it that if Nature had not implanted a trou-

blesome amount of affection in woman's composition, she could by her greater force of will and character drive man into a corner of the universe, just as the inferior races of the past have been driven before the superior ones—only more so, the disparity being greater.

This is not wholesome. If men have abused their power in the past, it is only what holders of power, who were also fallible mortals, might have been expected to do; and if women were wise, the lesson they would learn, now that they are more and more being placed in the way of acquiring power themselves, would be, if possible, not to abuse it so much as men in their day have done. There is little to be gained by turning the shafts of feminine wit against men, nor will the feminine character be improved by much indulgence in the practice. Better far will be a serious effort to rise to the level of their new opportunities and responsibilities. A man may be a great scholar and a great fool, and so, we venture to say, may a woman. It is a much easier thing to stimulate the intellect than to strengthen and enrich the moral nature; and it does not follow that, because women now have access to most colleges and universities, they are going at once to show a higher type of character. It is not impossible even that a reliance on those methods of culture which have been devised for men may tend to impair in a greater or less degree those finer intuitions which are claimed as the glory of the female sex, and in which we are quite prepared to declare our own firm belief. The intellectual differences between the sexes may be less than has hitherto been supposed; but there are differences nevertheless, and it is the manifest interest of the race that these should be developed and made prominent, rather than weakened and obscured. So greatly have the claims of women been advanced within the last half generation that it seems almost like offering an indignity to her present state to quote the lines of Tennyson so greatly admired in their day:

> "For woman is not undeveloped man,
> But diverse; could we make her as the man,
> Sweet love were slain."

Still, perhaps, there is wisdom in the words, and, if so, it might be well to suggest a caution lest, in the eager assertion on her part of equality in all points with man—not to say of superiority to him—something of inestimable value be, if not lost, allowed to fall into comparative disuse, with more or less of resulting injury.

If the human race is to endure, and if civilization is to advance, the relations between the sexes must not permanently be relations of rivalry. Men and women were not made to struggle with one another for the advantages of life, but mutually to aid one another in reaping those advantages. That "sweet love" of which the poet speaks is given as the reward of right relations between man and woman; and, where other guidance is lacking, we may profitably ask whether any given line of conduct tends to the gaining or the sacrificing of that reward. If to the former, then it may safely be said to be right conduct; if to the latter, wrong. What it is clear that man has to do in these later days is to frame to himself a higher and completer ideal of manhood than he has hitherto, on the whole, entertained, and try to live up to it. The awakened womanhood of the age—when allowance has been made for all that is hysterical and morbid and heartless in contemporary feminine utterances—summons him most clearly and distinctly to walk henceforth on higher levels in the strength of a nobler self-control. Then he has to recognize in the fullest sense, without a particle of reservation, that he has in woman not a weaker shadow of himself, not a reflection of his glory nor a minister to his pleasures, but a divinely bestowed helpmeet, to whom special powers and fac-

ulties have been imparted for the interpretation of truth and the beautifying of life. The ancient Germans, Tacitus tells us, used to recognize a certain divine power of intuition in their women, and if they did it was probably not without cause. The phenomenon is not an extinct one in our own day, and we venture to say that its frequency will wax or wane according to the respect paid not by man only, but by woman herself, to all in her nature that is most distinctive of womanhood. It is far from certain that woman always recognizes what her own best gifts are; and there is, in our opinion, a specific danger lest, in her new-born zeal for a masculine equipment of knowledge, she relegate to an inferior place that native truth of perception which is of more importance, we may almost say, than all formal knowledge.

The new times call for new virtues; and not too soon has man been awakened—or rather is he being awakened, for the process is far from complete—from what, with acknowledgments to Kant, we may call his "dogmatic slumbers." The Sphinx is at our gate again with its everlasting riddles, and woe betide us if we do nót solve them! For this will be needed the combined wit and wisdom of the best men and women of the time, and by the best we mean not those who pride themselves on the most encyclopedic knowledge, but those rather who with sufficient knowledge to understand the world around them can, by the exercise of the deepest human feeling, place themselves at the heart of the social situation, and so give us a clew to "the master knot of human fate." The great remedy for vain rivalry and stupid competition of wits is to join hands and hearts in useful work—in work for that universal humanity which, though not a fit object of worship, is at least an inspiring object of devotion.

THE MEANING OF DYNAMITE.

Mr. Auberon Herbert, in the May number of the Contemporary Review, discusses in a very philosophical spirit the dynamite outrages that have been occurring of late in Europe, and particularly in France. The dynamiter, he says in effect, is simply a man who, finding that governments are founded on force, and that in many cases they have no higher warrant than their irresistible power for the actions they perform, determines to get even with them by the only means within his reach. He has not learned "the trick of the majority," and so can not proceed openly to impose his will upon others. He can not uniform a policeman and arm him with club and pistol, so he arms himself with a dangerous and easily secreted explosive, and places it with lighted fuse where, from his point of view, it will do most good. At first sight it might seem that Mr. Herbert is maintaining an outrageous paradox; but it is not so: he is entirely serious, and, in our opinion, he fully establishes his thesis that over-government leads to dynamite. He cites France as a conspicuous example of an over-governed country, and cites a multitude of facts which show how little respect, in spite of the republican form of its institutions, is paid to individual liberty, how horribly the omnipresent power of government intrudes into the daily life of the citizens. Mr. Herbert goes on to say:

"What I have said of France might be said, with the necessary difference, of other European countries—each country being vexed and harassed by its bureaucrats, and each being affected in its own way according to the genius of the people. But in each country the general effect is the same. Almost every European government is a legalized manufactory of dynamiters. Vexation piled upon vexation, restriction upon restriction, burden upon burden—the dynamiter is slowly hammered out every-

where upon the official anvil. The more patient submit, but the stronger and more rebellious characters are maddened, and any weapon is considered right as the weapon of the weaker against the stronger."

England, the writer admits, is in a different position. "We have inherited," he says, "splendid traditions of voluntaryism, which hardly any other nation has inherited; and it is to voluntaryism, the inspiring genius of the English character, that we must look in the future, as we did in the past, for escape from all difficulties. If we can not by reason, by influence, by example, by strenuous effort, and by personal sacrifice, mend the bad places of civilization, we certainly can not do it by force." At the same time England has entered, he considers, on the dangerous path of paternal and protective legislation. As yet she has only soiled her ankles—so he expresses it—where other nations have waded deep, and it is not yet too late "to step back from the mire and slough which lie in front of her." The question is, Will she? Under the guise of socialism and humanitarianism, the spirit of compulsion is in the air. The well-meaning everywhere are longing to see whether they are not, or can not command, a majority in order that they may begin to wield that compulsive power which it is one of the strange delusions of the modern world that majorities have a right to exercise in everything. Yet if one were to propose to put any one of these well-meaning persons under the absolute control of another well-meaning person, who should prescribe for him his comings and goings, decide for him what causes he should support, how much money he should give in charity and for what particular objects, how much wealth he should accumulate and at what point the fruits of his industry should pass over to the state, we greatly fear that well-meaning person number one would make strong objections. True, he wants, with the aid of those who agree with him in opinion, to settle these points for others; but he has never seriously considered what it would be like to part with his own liberty. Ordinary human beings require something more than an assurance of another person's good intentions before they are willing to make a surrender to him of any large measure of their freedom of action; and we imagine that many of those who to-day advocate an indefinite increase in the power of the state do so under a fond impression that *their* particular views and schemes, humanitarian or other, will always prevail. They, with the help of others like-minded, want to govern the world for its good. Well, what tyranny ever professed less? Good intentions are excellent things to have, but when they make alliance with the policeman's truncheon they become committed to many devious lines of policy, and quickly assume all the odious characteristics of tyranny.

But does not the present unchecked action of *laissez-faire*, it may be asked, threaten danger to society? Society as an organism, we answer, will always be subject more or less to disturbances; but the important thing is to see that we do not interfere with the compensating actions which, like organisms in general when thrown out of equilibrium, it has the power to set up. Action and reaction in the social world, as elsewhere, are equal and opposite; and given the fact that man's instinct is to pursue happiness, and the further fact that the happiness of each individual is largely dependent on the dispositions of others, the actions and reactions taking place in a society not strangled by government control would steadily tend toward an increase of the general welfare. Public opinion is, in all free communities, a powerful agent of reform; but it would be still more powerful if it did not so often seek to embody itself in law. We have yet to be convinced that the world has suffered injury by any application of *laissez-faire*. Under that

régime things will not always be done rightly, but neither would they always be done rightly under any system of tyranny, socialistic or other, that could be invented. *Laissez-faire* was probably never carried further in the history of the world than in the early history of the several colonial communities which afterward combined to form these United States; and the principles of paternalism and protection in government were probably never carried further than in the management during the same period of the French colonies to the north and east of us. And what was the result in either case? The neglected colonies of England, with their very loose system of local government, grew strong and vigorous and wealthy, while the over-protected colonies of France seemed smitten with industrial and commercial paralysis. In war the latter were for the most part efficient and formidable, because then they acted in complete submission to leaders accustomed to command; but in peace they languished and withered. The English colonies, the New England ones in particular, might be compared to vigorous youngsters full of animal spirits, and meeting with many a disaster through their recklessness and impatience of control. The French ones, on the other hand, resembled puny and exacting nurslings always crying out for maternal help and succor. *Laissez-faire* has its drawbacks, but it means, on the whole, wealth, vigor, resource, and capacity for recuperation. It does not mean dynamite; the latter, as Mr. Auberon Herbert has well shown, being the natural concomitant of over-government.

LITERARY NOTICES.

Social Evolution. By Benjamin Kidd. New York: Macmillan & Co. Pp. 348. Price, $2.50.

This is a work marked to a more than usual extent by independence and originality of thought, and one which will set a great many persons thinking on new lines. After a careful perusal of it, however, we are led to doubt whether the author's own conclusions are very well matured. He has caught sight, as he believes, of some important principles hitherto unrecognized, or but imperfectly recognized, in the field of social philosophy, and with the eagerness natural to a discoverer he has communicated them to the world without waiting to determine their exact scope and application. The result is more or less of incoherence and not a little of apparent self-contradiction in what nevertheless is from first to last an interesting and impressive dissertation upon a most important subject.

Mr. Kidd's first chapter deals with The Outlook. He believes the world to be on the eve of great changes. "Social forces," he says, "new, strange, and altogether immeasurable, have been released among us. . . . The old bonds of society have been loosened; old forces are becoming extinct. . . . The air is full of new battle cries, of the sound of the gathering and marshaling of new forces and the reorganization of old ones." What is the meaning of it all? Science herself, Mr. Kidd tells us, "has obviously no clear perception of the nature of the social evolution we are undergoing." Well, then, who has? If Mr. Kidd, who claims above all things to be pursuing rigorously scientific methods, why should he deny science any share in his work? It seems to us that if Mr. Kidd, as a scientific man, can forecast the future of society, it would be only using words in their usual acceptation to say that "science" has, in a certain measure, solved the problem. Of course, if Mr. Kidd claimed to have a revelation from heaven, that would be a different thing; he claims, on the contrary, to be an out-and-out evolutionist, a Darwinian of the Darwinians, and a Weismannian to boot. He tells us a little further on that "the definition of the laws which have shaped, and are still shaping, the course of progress in human society is the work of Science, no less than it has been her work to discover the laws which have controlled the course of evolution throughout life in all the lower stages." So we have always thought; and we have felt sure that Science, as soon as she gathered and sifted a sufficiency of facts, would dem-

onstrate to the world that the one was her sphere quite as much as the other. It should be needless to add that such has been the conviction of all who have had any tincture of social philosophy ever since the early years of the present century, not to go further back.

But without entering too much into criticism we must endeavor briefly to set forth a few of Mr. Kidd's leading ideas. He finds that science is strangely at a loss respecting the meaning and function of systems of religion in man's life and history. Well, of course science has much to learn, else it would not be science, but theology, or some such privileged branch of human knowledge; and, having much to learn, she is as willing to learn from Mr. Kidd as from any one else. Mr. Kidd has reflected deeply on this question of the significance of religious systems, and he finds that their main, if not only, function is to supply the lack of a rational sanction for the conditions of progress. His third chapter has for title There is no Rational Sanction for the Conditions of Progress, by which he means that, when men exercise the self-control or exhibit that regard for the interests of others on which social progress depends, they act foolishly from the individual point of view—their conduct has no rational sanction. Religion, however, steps in and supplies an "ultra-rational" sanction, and the maintenance of that sanction is of such importance to the life of societies that Religion pushes Reason aside and condemns it to a position of inferiority in order that her work may not be interfered with. "There never can be," observes our author, "such a thing as a rational religion"; seeing that "the essential element in all religious beliefs must apparently be the ultra-rational sanction which they provide for social conduct." Or, as he puts it, with more precision, "a rational religion is a scientific impossibility, representing from the nature of the case a contradiction in terms." Different civilizations are simply the varying modes or systems of human life that have formed around different types of religious belief. When a religion dies the civilization dies also. It may linger for a while by virtue of the inertia of established forms, but the soul has gone out of it, and it soon falls into decay. Intellect the author speaks of as a "disintegrating principle" tearing asunder the fabrics which instinct has woven; but if we ask what useful function it performs, we do not get from the work before us—which, however, doubtless owes its origin more or less to intellect—any very satisfactory answer. It has had something to do, he seems to admit, with our progress in the arts and sciences; but its services are not acknowledged in any very liberal fashion; nor are we furnished with any indication of the limits which the author thinks should be set to the exercise of the intellect.

The author is emphatic in his assertion that social progress can only be made through the free action of natural selection, and he states that "the avowed aim of socialism is to suspend that personal rivalry and competition of life which not only is now, but has been from the beginning of life, the fundamental impetus behind all progress." One would suppose from this that he had no faith in socialism; and yet, in his chapter on Modern Socialism and elsewhere, he seems to anticipate great and beneficial results from a vast extension of socialistic legislation. The fact is that it is very difficult to fix with any certainty the author's position on many of the questions he discusses. The best chapter in the book, to our mind, is the one entitled Human Evolution not Primarily Intellectual, in which he points out, we think with truth, that "certain qualities, not in themselves intellectual, but which contribute to social efficiency, are apparently of greater importance" than purely intellectual ones in promoting civilization and strengthening the basis of national life. In a word, the race, on the whole, is not to the smart, but to the good, to those whose social instincts are strongest and social habits the best. The whole book is worth reading, but it should be read in a critical spirit, otherwise it will teach quite as much of error as of truth.

General Scott. Great Commanders Series. By General Marcus J. Wright. New York: D. Appleton & Co. Pp. 349. Price, $1.50.

Born a few years after the close of the Revolution, and living through the period of the civil war, Winfield Scott was contemporary with nearly all the important military

events in our country's history. He was a Virginian by birth, of Scotch ancestry. That the belligerent faculty which was afterward so valuable to his country was early developed, is shown in an anecdote of young Scott punishing a bully who was abusing the youth's Quaker teacher. Young Scott entered the legal profession, but in 1807 one of the incidents that foreshadowed the War of 1812 caused him to join a troop of militia cavalry. When a more serious incident occurred a year or two later, Scott received a commission as captain. When war was actually declared, he was made a lieutenant colonel, although being then only twenty-five years of age. General Wright gives a detailed account of the operations of this war, in which Scott won an enviable record for gallantry and a promotion to a generalship. General Scott had gained some experience in Indian fighting during the war with England, and saw more of the same kind of service in the troubles with the Sacs and Foxes, the Seminoles, and the Cherokees. He was sent to South Carolina at the nullification time to act in case of an outbreak. The chief part of General Scott's reputation was made in the round of successes constituting the war with Mexico. The siege and capture of Vera Cruz, the battle of Cerro Gordo, and the operations around the capital city ending in Scott's triumphal entry, are described with gratifying fullness. The rest of the volume is occupied with minor events, including his nominations for the presidency, his honors, travels, administration of various military affairs, his retirement from the chief command of the army at the beginning of the civil war, etc. The various controversies in which a strong will and somewhat choleric disposition involved him are not concealed, and a wealth of anecdote illustrates all sides of his character. A frontispiece, portrait, and several maps illustrate the chronicle.

Aphorisms from the Writings of Herbert Spencer. Selected and arranged by Julia Raymond Gingell. With Portrait. New York: D. Appleton & Co. Pp. 166. Price, $1.

"How to live? that is the essential question for us Not how to live in the mere material sense only, but in the widest sense. The general problem which comprehends every special problem is the right ruling of conduct in all directions, under all circumstances." (Education, chap. i.)

This is the first selection in the volume. For many centuries man has been working out the solution of the problem to which it refers, and has made the best progress within the past generation. Just as his empirical knowledge of bodily hygiene has been greatly extended by the discovery of micro-organisms, so has his understanding of right conduct been broadened and systematized by the doctrine of evolution. Miss Gingell has made her book of extracts bear largely upon the management of life. Mr. Spencer being the chief exponent of evolution, the principles of conduct found in his writings are coordinated and unified by that great luminous truth which both lights up the past and enables us to peer into the future. This collection of aphorisms consists of brief, pithy sentences and paragraphs culled from the whole range of Mr. Spencer's writings and grouped under such headings as education, evolution, politics, justice, sympathy, happiness, etc. It has never been any part of Mr. Spencer's plan to prepare material that could be used in this way. The units of his writings are the chapters, and a passage taken out from its context is apt to give a misleading impression when standing alone. Yet Miss Gingell has carried out her undertaking with much tact, and the volume furnishes a sample of Spencer's quality from which readers may decide whether or not they desire to read any of his connected works.

Materials for the Study of Variation, treated with Especial Regard to Discontinuity in the Origin of Species. By W. Bateson, M. A. Cambridge. London: Macmillan & Co., 1894. Pp. 598. Price, $6.50.

The first portion of the above title is printed on the back of the book, and, considered under this title alone, Mr. Bateson has made a most valuable contribution to the study of variation. He has classified the phenomena, so to speak, and given some new and convenient terms to express the kinds of variation. The phenomenon of the repetition of parts he terms *merism;* numerical and geometrical changes are called *meristic*

changes; changes in the constitution or substance he calls substantive variation, and these various changes may be continuous or discontinuous. The word *homœosis* is substituted for metamorphy—this term being applied to cases such as the eye of a crustacean developing into an antenna, or the petal of a flower into a stamen, etc. He has systematized the sports, freaks, and redundancies of Nature, and has done an amazing amount of hard work in a field to which few have been hitherto attracted. He has also emphasized in the most telling way one of the most important factors in the doctrine of natural selection—namely, variation. As to the author's conception that the discontinuity of species is at all sustained by this evidence, we can not agree. His introductory pages—and there are many of them—are as laborious reading as similar portions of Buckle's History of Civilization. Man's power of apprehension, nowadays, has so far advanced that there is no longer any necessity for iterating and reiterating self-evident propositions.

Demonstrating, as he does, sudden and spontaneous modifications in animals, he assumes, without sufficient proof, that the divergent characters of many species have originated in this way. He asks, May not specific differentiation have resulted from individual variation? The answer to this would be that if these extraordinary jumps are ever perpetuated for a time even, like the double operculum in *Buccinum undatum*, for example, which he cites, the wildest species-maker has never dreamed of making a separate species of such freaks. They are hardly accounted varieties.

The author says that Lamarck's view points out that living things can in some measure adapt themselves, both structurally and physiologically, to new circumstances, and that in certain cases the adaptability is present in a high degree. He also formulates Darwin's theory as showing the survival of those adapted to the environment. "According to both theories, specific diversity of form is consequent upon diversity of environment, and diversity of environment is thus the ultimate diversity of specific form. Here, then, we meet the difficulty that diverse environments often shade into each other insensibly and form a continuous series, whereas the specific forms of life which are subject to them on the whole form a discontinuous series." We should question this latter statement. We have, for example, the two great provinces of land and water; we have also marked and emphatic divergencies in these larger provinces; the deep, moist cañon in an arid plain, the sharp line between light and darkness with their appropriate forms salt and fresh water, with the intermediate brackish water and the paucity of brackish water forms, and these pointing to their evident origin and subsequent adaptation; and rivers flowing through limy and granitic regions, with examples of mud lakes, sand lakes, and salt lakes. Indeed, the zones of demarcation are often so narrow that the varieties due to these selective features struggle almost hopelessly to keep up an existence.

Mr. Bateson seems to think that physical environment is the only selective action in the struggle for existence; but to those who have studied Darwin there are many other features to be taken into account, of which no mention is made. Ignoring the theory of natural selection, but recognizing the prime importance of variation as the essential phenomenon of evolution, he says, "Variation, in fact, is evolution." He overlooks the importance of all other factors upon which the theory of natural selection rests—inheritance, without which the theory would fall; the numerical proportion of individuals remaining the same, without which fact it could not be shown that an infinitely greater number of individuals perish than survive.

These equally important factors are laid aside, and he emphasizes the statement that variation, in fact, is evolution. This is as logical as if one should say evolution could not exist without life, life could not exist without oxygen (omitting certain forms of bacilli), and hence oxygen is evolution.

He repudiates the law of Von Baer, and says "it has been established almost entirely by inference, and it has been demonstrated in scarcely a single instance." Mr. Bateson can not understand why one species of moth differs a little in pattern from another species. He can not understand the utility of small differences which distinguish species. In his regard for species he should be reminded of the large number of species formerly considered good which have merged

into others as varieties or subvarieties. Many of these species, furthermore, were made by keen observers who devoted their whole time to making them, and were adepts at the work, and yet in the light of the studies of Baird, Coues, Allen, Ridgway, Brewer, and others these specific distinctions have been broken down, and many of these formerly well-recognized species are now known as geographical varieties.

His work is filled with a large number of cases of deformation, atrophy, hypertrophy, duplication of parts, etc. Varietal groups are one thing; double-headed monsters, supernumerary digits, etc., are quite another thing, and no one has ever been tempted to look in that direction for new species; indeed, the collector has rarely been inclined to save such freaks, and so Mr. Bateson's book is all the more remarkable for presenting such a large array of material.

After turning the last page we say to ourselves, If such profound structural divergencies can arise, how elastic the organism must be, and how infinite must be the number of minor variations of strength, endurance, color, proclivities, etc., which is all the material the Darwinian demands to sustain the doctrine of natural selection as an all-sufficient cause!

Total Eclipses of the Sun. By Mabel Loomis Todd. Columbian Knowledge Series. Number 1. Edited by Prof. David P. Todd. Boston: Roberts Brothers Pp. 244. Price, $1.

The opening volume of the Columbian Knowledge Series is a remarkably picturesque book. Dealing with those impressive moments, of infrequent occurrence in any one locality, when the face of Nature seems transformed, it appeals strongly to popular interest. Moreover, the fact that these occasions afford rare and precious opportunities for valuable scientific observations makes the subject doubly attractive to all intelligent minds. Mrs. Todd has made excellent use of her opportunities. With rare powers of description she tells how eclipses occur, describes their phenomena, and relates the incidents of various expeditions for observation. A historical sketch of eclipses from the remote past down to 1893 is given. Considerable is told about instruments and photographic appliances used in observing eclipses. A notably interesting feature is a list of future total eclipses of the sun, with a chart showing where they will be visible, and there is a similar list and chart of past eclipses since 1842. The proofs of the book have passed under the scrutiny of Prof. C. A. Young as well as that of Prof. Todd, so that readers need have no fears of inaccuracies. The volume is copiously illustrated and has an index.

Popular Lectures and Addresses. Vol. II. Geology and General Physics. By Sir William Thomson (Baron Kelvin). London and New York: Macmillan & Co. Pp. 599.

The volume of Lord Kelvin's Popular Lectures now issued completes the set of three volumes. Among the subjects discussed in the geological papers and addresses are geological time, geological dynamics and climate, the doctrine of uniformity, the internal condition of the earth, and polar ice-caps. In one of the addresses delivered before the British Association, Lord Kelvin has discussed the sources of available energy in Nature, designating them briefly as tides, food, fuel, wind, and rain, all but the first of which are derived from the sun. There are also addresses, more general in character, delivered at the opening of the Bangor laboratories, at the unveiling of a statue of Joule, and at three anniversary meetings of the Royal Society.

Public Libraries in America. By William I. Fletcher. Columbian Knowledge Series. Boston: Roberts Brothers, 1894. Pp. 169. Illustrated. Price, $1.

Every essential fact regarding the public libraries of America is here told in brief compass by the eminent librarian of Amherst College. The claims of the public library as a means of refined entertainment, as a gainful partner to the school, the workshop, and the studio, as here set forth, are certainly weighty enough for national conviction. To the public-spirited men and women who either wish to improve a library already established, or who desire to found one, Mr. Fletcher's chapters are indispensable. He concisely passes in review the selection of books, their fit housing, and the management of a library, this last task now much lightened for trustees and

committees by the library schools at Albany, Brooklyn, and at Amherst, where Mr. Fletcher himself presides. In discussing library foundations our author commends those created by gift, yet he observes that an institution is nearer the popular heart when spontaneously built up and controlled by the community it serves. Basing a forecast upon the recent rapid growth of public libraries, not only in number but in usefulness, Mr. Fletcher expects in the future a still further expansion for them. In this connection a list published last April by the Public Library of Paterson, N. J., is significant. This list presents works on astronomy, selected by Prof. C. A. Young, of Princeton, who appends brief notes to the principal titles. Lists such as this, ampler in range and fuller in annotation, would double the value of every public library incorporating them in its catalogue. At one pole of education are the teachers of mark who can appraise the working literature of instruction, at the other pole are unnumbered inquirers at library desks who know not what to choose; to bring together the trustworthy guides and the baffled wanderers would mark a new era in popular enlightenment, would break down another wall dividing those who need from those who have and are willing to give.

Pain, Pleasure, and Æsthetics: An Essay concerning the Psychology of Pain and Pleasure. By Henry Rutgers Marshall, M. A. London and New York: Macmillan & Co. Pp. xxi + 364. Price, $3.

There is a certain smoothness, sobriety, and clearness about this work of Mr. Marshall that appeals with peculiar emphasis alike to the artist and the scientist. At once the æsthetic taste and the spirit of scientific inquiry are in a large measure satisfied. The author, indeed, is open to admit that this is by no means a subordinate aim in the volume under consideration. As is plainly manifest, he comes as a peace-maker between the artistic aspirant who misconceives or deems the teachings of science antagonistic to his favorite pursuit, and the scientific investigator who suspects artistic predilections as either inimical to or in the way of science. Nothing that ministers to the melioration of that harmonious understanding which ought to have obtained where it was lacking, has been kept out of sight, and happily for two great departments of learning, a literary link has been added to the chain of progress. While the work, in its seven tersely written chapters, treats mainly of psychological problems, the undertone, apart from the author's prominent design, is essentially æsthetic in its tendencies, a fact that forms almost imperceptibly a mental meeting ground for scientist and artist. Chiefly, the latter is impelled by an inner and perpetual voice which expressly commands him to act. But he is primarily a listener, an interpreter of high and noble promptings. As such, he can have naught against the "physical discoverer," to whom, as Tyndall has admirably put it, "imagination becomes the mightiest instrument." In turn, the scientist is indebted beyond measure to the genius of art, and gains from it in regions decidedly æsthetic many of the joys of life, which indirectly contribute and betimes directly suggest his boldest flights and most clearly conceived problems.

The book abounds with interesting comparisons grouped within well-defined limitations. With a psychological classification of pleasure and pain, the reader is asked to contemplate the instincts and emotions, the field of æsthetics, the physical basis of pleasure and pain, and algedonic æsthetics. The work as a whole is a general as well as technical survey of comparatively new ground.

The Law of Psychic Phenomena. By Thomson Jay Hudson. Chicago: A. C. McClurg & Co. Pp. 409. Price, $1.50.

Those who are interested in the outlying parts of the field of psychology will welcome this book. It is a treatise on hypnotism, mental healing, spiritism, telepathy, clairvoyance, and allied subjects, by one who is convinced of the reality of such manifestations and seeks to explain them as caused by natural, though unfamiliar workings of the human mind. The "law" referred to in the title is also described as a working hypothesis which is expected to guide further study of psychic phenomena. It is stated in three propositions: First, "Man has, or appears to have, two minds, each endowed with separate and distinct attributes and powers; each capable, under certain conditions, of independent action. . . . The second proposition is,

that the subjective mind is constantly amenable to control by suggestion. The third, or subsidiary, proposition is, that the subjective mind is incapable of inductive reasoning." The author proceeds to discuss the various classes of psychic phenomena on the basis of these propositions, especial attention being given to "psycho-therapeutics," or healing by suggestion. He analyzes carefully the results obtained by the prominent investigators of hypnotism, rejecting many of the inferences of certain too enthusiastic hypnotists. He denies that a hypnotic subject can be led into criminal acts by suggestion when the subject would not commit such acts independently. The common principle underlying the healing effect of the faith cure, mind cure, Christian science, etc., is sought for, and a new system of mental therapeutics is then set forth. The author accepts the phenomena of spiritism as realities, but denies that they are produced by the agency of the dead. In the closing chapters the physical manifestations and the spiritual philosophy of Christ are discussed. The book is temperate in tone, and its style is graceful and concise.

Minerva. Jahrbuch der gelehrten Welt (Minerva. Year-Book of the Learned World). Edited by Dr. R. Kukula and K. Trübner. Third Year: 1893-'94. Strasburg, Germany: Karl J. Trübner. Pp. 861.

The compilers profess in this, the third year's issue of their work, to have endeavored to approach still nearer to their purpose, which is defined to be to furnish the most authentic and complete data possible concerning the scientific institutions of the whole world. The accounts of many institutions have been made more complete, and others which were wanting have been added. Of German institutions the more important archives have been revised and a number of libraries not before included; of Austrian, the archives and the university institutes; of French, the provincial libraries, for which last the special services of Ulysses Robert, inspector-general of French libraries and archives, are acknowledged. Other additional and fuller facts have been furnished concerning Scandinavian and Russian institutions by Prof. Lundell, of Upsala. Assistance has been given by Signor Chilovi, of the National Central Library in Florence; Prof. T. E. Holland, of Oxford; Prof. J. E. Sandys, of Cambridge; Prof. Gallie, of Utrecht; Prof Nicholas Murray Butler, of New York; and others in Bucharest and Vienna. Dr. Reinold Rost, of the India Office, London, describes the institutions of India, and Dr. Vallers, of Cairo, the Arabian Academy of that place. The volume contains a list of the institutions arranged geographically; descriptions of technical and agricultural high schools, veterinary schools, academies of forestry, and other independent scientific institutions, libraries, and archives, arranged in alphabetical order; statistics of students attending the institutions; and a personal register. In the United States are described twenty-eight universities and colleges, two technical schools, two theological seminaries, twenty-seven libraries (not college libraries), nineteen independent observatories, four learned societies (in New York and Philadelphia), six museums, and the department institutions in Washington.

The *Report* for 1892, of the *Board of Control of the New York Agricultural Experiment Station* notices the improvements that were made in the property of the station, and carries with it, in the reports of the director and others, accounts of the researches that were carried on. These researches, which were also the subject of bulletins, concern the feeding of hens and chickens, black knot on the plum and cherry, spraying with fungicides, analyses of materials used in spraying and the influence of copper compounds in soils on vegetation, analysis of commercial fertilizers, the manufacture of cheese, and diseases of the bean. An address by Director Peter Collier on What is the New York Agricultural Experiment Station doing for the Farmer? is published in the report, and conveys much information concerning the general working of the station and its usefulness.

Dr. *Eduard Suess*, Professor of Geology at the University of Vienna, published a volume a few years ago on The Future of Gold, in which he tried to show that from geological indications we must expect in the future a scarcity of gold and an abundance of silver, and that the extension of the gold standard to all civilized states is impossible.

In 1892 he published a work on the *Future of Silver*, which, translated by Robert Stein into English, is now printed and circulated by the Finance Committee of the United States Senate. In this essay the author reaches the conclusion that, assuming that the system of metallic coinage continues to exist, silver will become the standard metal of the earth, and that "the question is no longer whether silver will again become a full-value coinage metal over the whole earth, but what are to be the trials through which Europe is to reach that goal."

Charles Denison's Climates of the United States, in colors, already well known in its form in charts, has been revised and condensed in dimensions, and is now published in a convenient little volume by the W. T. Keener Company, Chicago. It gives in maps, with scales of colors graphically showing the intensity of the phenomena in the different regions, the average annual cloudiness, rainfall, temperature, and winds, the elevations of different regions, and the combined atmospheric humidities and seasonal isotherms and wind indications for each of the seasons throughout the whole United States, excepting Alaska.

Dr. *Adolf Brodbeck*, of Zurich, believes that in his little pamphlet, *Die Zehn Gebote der Jesuiten* (The Ten Commandments of the Jesuits), the truth about the Jesuits and their relation to Christendom is said for the first time. The authorities on which he relies are the classical writings of the order.

George H. Boehmer prefaces an interesting study of the *Prehistoric Naval Architecture of the North of Europe* (United States National Museum) with a brief notice of Greek and Roman boats, the constructions of the Germans, and such ancient boats as have been found in England. By far the largest part of the paper is devoted to Scandinavian boats, of which a considerable number have been found in the northern countries. This gives opportunity to describe the situations and positions of these boats, their surroundings, and the articles which were found with or near them, so that incidentally much information is conveyed concerning Scandinavian archæology in general.

Christ, the Patron of all Education, is the title of a sermon preached by the Rev. *Charles Frederick Hoffmann* before St. John's Guild of Hobart College, on the occasion of the commencement of that institution in 1893. It is published, by request of the guild and of members of the college faculty, by E. and J. B. Young & Co., New York. In company with it the same house publishes, also by request, an address delivered by Dr. Hoffmann on the occasion of the laying of the corner stone of St. Stephen's College, Annandale-on-the-Hudson. The subject is The Library of a Divine Child.

The composition of *The Study of the Biology of Ferns by the Collodion Method* was begun by *George F. Atkinson* after he had been successful in applying the method in his classes to the preparation of the very delicate tissues of ferns, and especially to the infiltration of prothallia without shrinkage. He started to prepare a simple laboratory guide, giving directions for preparing the various tissues, with a few illustrations, made chiefly from preparations put up by students in their regular work, together with some descriptive matter. Gradually other features were added, and the book grew to its present volume of 134 pages, constituting a fairly full technical manual. The first part is descriptive of the life cycle of ferns, their reproductive organs, parts, growth, and functions. The second part relates to methods of preparation and examination. The study is published by Macmillan & Co., New York, at the price of $2.

The *Eighteenth Annual Report of the Secretary of the Michigan State Board of Health* for 1889–'90, besides the regular matter of official routine in the first part, contains in a second part a number of papers, abstracts, and reports, among which are one on the Principal Meteorological Conditions in Michigan in 1889; one on the Time of Greatest Prevalence of each Disease, being a study of the causes of sickness in the State; and one on Dangerous Communicable Diseases in Michigan in 1889, relating to diphtheria, smallpox, measles, scarlet fever, typhoid fever, whooping-cough, pneumonia, dysentery, glandular hydrophobia, and lump-jaw. *Henry B. Baker*, Secretary, Lansing.

The Rev. *T. W. Webb's* very useful and convenient work on *Celestial Objects for Common Telescopes*—a fitting companion for Mr. Serviss's Astronomy with an Opera

Glass—has been revised and greatly enlarged for the fifth edition by the Rev. T. E. Espin, and is now published by Longmans, Green & Co. in two volumes. Preparatory to beginning his work on the new edition the author invited suggestions from amateurs, obtained advice from the Astronomical and Statistical Society of Toronto, and received assistance from special students of the sun, the moon, the planets, the comets, and meteorites. The original text has been left unaltered as far as possible, and the new matter added is placed in footnotes. The catalogue of Struve has been used as a basis. The objects have been arranged in the order of their right ascensions in the constellations.

The most important event mentioned in the *Report of the Harvard Astronomical Observatory* for 1893 is the completion of the new fireproof brick building, and the transfer to it of about 13,000 stellar photographs. The entire income of the Paine fund has become available for the use of the observatory. Photographing celestial objects under the Henry Draper memorial continues. The most important object taken is a new star in the constellation Norma, July 10th, which has a spectrum appearing idencal with that of Nova Aurigæ. A higher meteorological station has been established in Peru than even Chachani. It is on the summit of the volcano El Misti, 19,200 feet above the sea. The latest publications of the *Annals of the Observatory* received by us are Vol. XIX, Part I, Researches on the Zodiacal Light and on a Photographic Determination of the Atmospheric Absorption; Vol. XXV, Comparison of Positions of the Stars between 49° 50′ and 55° 10′ North Declination, between 1870 and 1884, by W. A. Rogers; Vol. XXIX, Miscellaneous Researches made during the Years 1883-'93; Vol. XXX, Part III, Measurements of Cloud Heights and Velocities at Blue Hill Meteorological Observatory, by H. H. Clayton and S. P. Ferguson; Vol. XXXI, Part II, Investigations of the New England Meteorological Society for the year 1891; Vol. XL, Part II, Observations made at the Blue Hill Meteorological Observatory in the year 1892.

It is only by degrees and with difficulty that the study of natural science has been able to draw away from the domination of older subjects of instruction. The early guides in the experimental method unavoidably retained too much of the character of text-books. In *Laboratory Studies in Elementary Chemistry*, prepared by Prof. *Le Roy C. Cooley* (American Book Company, 50 cents), an especial effort has been made to secure purely experimental study, which is something more than verifying statements found in books. Directions for a hundred and fifty experiments are given, and the student is told the object of each, but not what he is expected to see. At the close the application to qualitative analysis of the facts and principles learned is pointed out.

The Problem of Manflight is considered by *James Means* (W. B. Clarke & Co., Boston, publishers, 10 cents) from the point of view that the solution is to be sought in the principle of the soaring of birds. The author calls attention to the fact that the feat of safely sliding down a long and gentle incline upon an aëroplane has been performed by Otto Lilienthal, of Steglitz, Prussia, and adds that "in order to travel long distances in the air it is only necessary to improve the dirigibility of the aëroplane so that the angle of descent can be brought to a minimum." This can be done by making repeated experiments with very simple and inexpensive mechanical contrivances called soaring machines, these to be dropped from a height. Experiments with machines of this kind should be encouraged, with regattas and large prizes. With machines made automatic in their steering action, flights like Lilienthal's will be no more dangerous than football, quite as interesting, and far less barbarous.

A preliminary study of *The Derivation of the Pineal Eye* is published by William A. Locey, of Lake Forest, Ill., in the Anatomische Anzeiger, of Jena.

The *State Library Bulletin, Legislation*, comprises a classified summary of new legislation, with a subject index, which is prepared by entries on cards made as fast as proofs or advance copies of the session laws can be secured. This index is printed at the beginning of each year in order to inform legislators and other State officers what of special value in the subject under consideration in the publications of other States is available in the New York State library. The references in Bulletin No. 4, January, 1894,

cover the laws enacted in 1893 by thirty-nine States and one Territory. In most cases the laws are briefly summarized as well as cited, in order to present clearly and concisely material for comparative study of the most recent phases of State legislation on all subjects of general interest. (Published by the University of the State of New York, Albany. Price, 20 cents.)

In a paper on the *Prevention of Tuberculosis in Ontario*, read before the Ontario Medical Association, Dr. *E. Herbert Adams* advocates such measures of administration and education as will make sure the total destruction of the products of expectoration, and of the germs of the disease in every other form.

The *Journal of Social Science*, No. XXXI, January, 1894, includes more than half of the Saratoga papers of 1893. The one occupying the first place, and probably of widest general interest, is the tribute of Mr. Edward B. Merrill to the life and public service of George William Curtis. Other papers are the report of F. B. Sanborn on Socialism and Social Science; a review of recent progress in Medicine and Surgery, by Dr. Frederick Peterson; Compulsory Arbitration, by H. L. Wayland, D. D.; three papers in the Finance Department, relating to the silver question, bimetallism, and The Three Factors of Wealth; three papers in the Social Economy Department—two of them relating to Mutual Benefit Societies and the Sweating System; three papers in the Jurisprudence Department; and The Education of Epileptics, by Dr. L. F. Bryson. (Published by G. P. Putnam's Sons, New York, and Damrell & Upham, Boston.)

In planning his *First Course in Science*, the author, *John F. Woodhull*, believing that the study of text-books alone can not be classed as work in science, and that illustrative or object teaching can be so classed only in part, has attempted to devise means by which apparatus could be put into the hands of each pupil as early as possible. A text-book, however, is essential, and it is given here in two separate but mutually dependent volumes. One volume contains directions to pupils for performing their experiments, sufficient to prevent aimless work, and yet not so full as to interfere with the inductive method. The other volume, the Text-book, is similar to the ordinary text-book, telling how the experiments should result, giving the pupil a correct form of statement for the conclusions and laws which he has learned in a practical way, and furnishing other information. The experiments are on light. On every right-hand page in the Book of Experiments is left a space for the insertion of the pupil's own notes. (Published by Henry Holt & Co., New York. Price of the parts, 50 cents and 65 cents.)

Prof. *Max Müller*, replying to an accusation that his book on the *Science of Thought* was thoroughly revolutionary and opposed to all recognized authorities in philosophy, describes it as rather evolutionary, the outcome of that philosophical and historical study of language which began with Leibnitz and has now spread and ramified so as to overshadow nearly all sciences. The fundamental principle of the book is that language and thought are identical, and one can not be without the other. The three lectures on the subject published by the Open Court Publishing Company, Chicago, are regarded by the author as a kind of preface or introduction to the larger work. To these lectures are added in an appendix the correspondence between Prof. Müller and Francis Galton, the Duke of Argyll, George J. Romanes, and others, on Thought without Words. The lectures are sold, bound in paper, for 25 cents.

The papers in the fourth number of Volume II of the *Bulletin from the Laboratories of Natural History of the State University of Iowa* are technical. Mr. B. Shimek's account of A Botanical Expedition to Nicaragua has a few features of general interest, but the author's mind was too singly fixed upon his collections to permit him to enlarge upon them. Of the other papers, four are upon the slime-molds and other fungi of Nicaragua, Central America, eastern Iowa, and Colorado; two relate to the physiology of the Coleoptera; two, by F. S. Aby, relate to the physiology of the Domestic Cat, and to observations on a case of Leucæmia; and A New Cycad is described by Thomas H. McBride. (Iowa City, Iowa. Price, 50 cents.)

The work described in the *Report of the Botanical Department of the New Jersey Agricultural College Experiment Station for 1892*

relates chiefly to fungous diseases of plants and to weeds. One of the leading diseases investigated has been a serious trouble among beans, producing brown irregular pits on the pods and seeds. This was shown to be due to bacteria. Much attention has been given to fruit diseases and rose troubles; diseases of the violet, nasturtium, and sedum have been studied also. Under the study of weeds the root system has been an objective point. The great size attained by tap roots of some weeds, and the wide extent over which other species may spread under ground, have been shown. The manner in which weeds pass the winter and their agency in propagating fungi have also been looked into.

A thoroughly practical address on *Heating and Ventilation of Residences*, delivered by *James R. Willett* to the engineering societies of the University of Illinois, has been printed by the author. Three modes of heating—by hot water, steam, and hot air—are described in it. Mr. Willett tells how to estimate the amount of radiating surface or the sectional area of hot-air pipes required for a house, how to determine the grate area, the sizes of fittings, and the proper location for all parts of a heating apparatus. There are sixteen plates showing plans and elevations of heating apparatus in houses. Further information is given in tables and in cuts in the text.

In the belief that spelling would be learned incidentally from language lessons, the set study of this subject has been largely discontinued. This belief has proved erroneous in many cases, and a return to the old practice is being made. The renewed demand for spelling books has led to the publication of *The Limited Speller*, by *Henry R. Sanford*, Ph. D. (Bardeen, 35 cents), designed to include all the words in common use which are frequently misspelled. The words are arranged in one alphabetical list, the accent is always marked, and the pronunciation is indicated wherever necessary by diacritics or respelling.

With its number for December, 1893, *New Occasions* began its second volume in a new form and with more pages (Charles H. Kerr & Co., $1 a year). It is edited by *B. F. Underwood*, and is devoted to social and industrial progress. The enlarged size was made necessary by an arrangement to print in the magazine the lectures of the Brooklyn Ethical Association for the past winter. The December number contains the first of these lectures, on Cosmic Evolution as related to Ethics, by Lewis G. Janes. Dr. Janes asks the question, "Can an ethical science be formulated in harmony with cosmic law sufficiently rational and broad to command the allegiance of all liberal-minded people?" and gives some considerations in favor of an affirmative answer. Other topics treated in this number of the magazine are the pardon system, immigration as affected by the tariff, the Eliot-Lewes marriage, and there are briefer articles under the general head of Occasions and Duties.

Many persons are looking to science for some kind of substitute for religion, and several attempts have been made to satisfy this expectation. Among the latest of these is that made by Dr. *Paul Carus* and embodied in *The Religion of Science* (Open Court Publishing Co., 25 and 50 cents). The author's system imitates the form of traditional religion quite closely, while rejecting revelation and anthropomorphism. The religion of science, he says, accepts "Entheism," and he defines this as "the view that regards God as inseparable from the world. He is the eternal in Nature." The authority for conduct in his plan is the system of laws of the universe. Its ethics is the ethics of duty. Its conviction as to immortality is that the soul persists—not as an individual existence—but that it becomes merged in the "soul of mankind." Further resemblances and differences between the new doctrine and the old are set forth in chapters on Mythology and Religion; Christ and the Christians, a Contrast; and The Catholicity of the Religious Spirit.

The *Annual Report of the Chief of Engineers, United States Army, 1893, Part I*, is occupied mainly with accounts of improvements in rivers and harbors on which work was done in the year ending June 30, 1893. Operations were carried on at many places along the Atlantic coast and the Gulf of Mexico, from the St. Croix River in Maine to the harbor at Brazos Santiago, Texas. The Western rivers, the lake harbors and rivers, and the Pacific coast also received considerable attention. Other work done by the engineer corps concerned the bridging of

navigable waters of the United States, public works in the District of Columbia and the Yellowstone National Park, etc.

An essay on the *History of the Philosophy of Pedagogics*, by *Charles W. Bennett*, LL. D., has been published in book form (Bardeen, 50 cents). It sketches the attempts that have been made during the past four or five centuries to base education upon some one principle. The educational work of the religious reformers, abstract theological education, Jesuitism, Jansenism, pietism, realism, humanism, and deism are passed in review, and freedom of activity is described as the final stage. Portraits of leaders of educational thought, from Erasmus to Froebel, are inserted in the text.

In *The Educational Labors of Henry Barnard*, by *Will S. Monroe* (Bardeen, 50 cents), have been chronicled a series of efforts for the uplifting and advancement of education that have seldom been equaled in value. State Superintendent of Education in Connecticut from 1838 to 1842 and 1851 to 1855, holding the same office in Rhode Island from 1842 to 1849, President of the University of Wisconsin, and later of St. John's College at Annapolis, and United States Commissioner of Education from 1867 to 1870, Mr. Barnard has had many and important fields of usefulness. In 1855 he founded the American Journal of Education, of which thirty-one volumes have been issued. Four portraits of Mr. Barnard and a bibliography of his writings are included in the volume.

PUBLICATIONS RECEIVED.

Adler, Hermann, M. D. Alternating Generations. A Biological Study of Oak Galls and Gall Flies. Translated and edited by Charles R. Stratton. New York: Macmillan & Co. Pp. 198, with Plates. $3.25.

Agricultural Experiment Stations. Bulletins and Reports. Connecticut: Seventeenth Annual Report. Pp. 331.—Babcock Test for Cream. Pp. 240.—Michigan: Fruit Bulletins. Pp. 135.—Bulletins 107 to 110. Lambs, Potatoes, Vegetables, and the Horse. Pp. 100.—Storrs, Conn.: Sixth Annual Report. Pp. 200.

Carnegie, Douglas. Law and Theory in Chemistry. New York: Longmans, Green & Co. Pp. 222. $1.50.

Cline, I. M. Climate and Health of Galveston, Texas. Pp. 7.—Summer Hot Winds on the Great Plains. Pp. 40.

Correspondence School of Technology. Cleveland, Ohio. Catalogue. Pp. 23.

Cragin, Prof. F. W., Colorado Springs, Col. Vertebrata from the Neocomian of Kansas. Pp. 4.—New and Little-known Invertebrata from the Neocomian of Kansas. Pp. 12.

Ewing, J. A. The Steam Engine and other Heat Engines. New York: Macmillan & Co. Pp. 400. $3.75.

Fewkes, J. Walter, Boston. Dolls of the Tusayan Indians. Leiden. Pp. 30, with Plates.

Foley, William C. Armor Protection for Heavy Guns in Battle Ships. Pp. 12.

Hague, Arnold. The Yellowstone Park. Pp. 24.—The Great Plains of the North. Pp. 6.

Harris, W. T. Report of the Commissioner of Education for 1890-'91. Two Volumes. Pp. 1549.

Holt, L. Emmett. The Care and Feeding of Children. New York: D. Appleton & Co. Pp. 63. 50 cents.

Huxley, T. H. Man's Place in Nature. New York: D. Appleton & Co. Pp. 328. $1.25.

Keen, W. W., M. D. Ligation of the Common and External Carotid Arteries and the Jugular Vein. Pp. 3.—Operation Wounds of the Thoracic Duct in the Neck. Pp. 10.—Removal of the Gasserian Ganglion for Tic Douloureux. Pp. 14.—Oval Hæmorrhoid: Operation and Cure. Pp. 4.

Lewis, the late Henry Carvill. Papers and Notes on the Glacial Geology of Great Britain and Ireland. Edited from his unpublished manuscripts, with an Introduction by Henry W. Crosskey. New York: Longmans, Green & Co. Pp. 469.

Lockwood, Jean Boag, General Manager. The Epitome. Monthly. May, 1894. Vol. 1, No. 1. Pp. 64. 20 cents, $2 a year.

Lonsdale, E. H. Southern Extension of the Cretaceous in Iowa. Pp. 10.

Marine Biological Laboratory. Sixth Annual Report for the Year 1893. Boston. Pp. 46.

Marshall, the late Arthur Milnes. Biological Lectures and Addresses. New York: Macmillan & Co. Pp. 366.

Mason, Otis T. The Birth of Invention. Pp. 12.—The Progress of Anthropology in 1892. Pp. 48. Technogeography, or the Relation of the Earth to the Industries of Mankind. Pp. 24.

Missouri. Twenty-fifth Annual Report of the Superintendent of the Insurance Department. Pp. 28.

"Ormond." Suggestive Essays on Various Subjects. Creation *vs.* Evolution. Chicago: The Blakely Printing Company. Pp. 67.

Palmer, Julius A. About Mushrooms. Boston: Lee & Shepard. Pp. 100. $2.

Powell, J. W., Director. Twelfth Annual Report of the United States Geological Survey. Two Volumes. Pp. 675 and 576, with Maps and Plates.

Shufeldt, R. W., M. D. Comparative Oölogy of North American Birds. Pp. 32.—Scientific Taxidermy for Museums. Pp. 72.

Silberstein, Solomon. Six General Laws of Nature. New York. Pp. 40.

Slater, John F. Fund for the Education of Freedmen. Proceedings of the Trustees. Pp. 42.

Smithsonian Institution. List of Publications for Sale or Exchange. Pp. 26.

Spratt, Leonidas, Jacksonville, Fla. Man in Continuation at this Earth of a Nature of Reality throughout the Universe. Pp. 109.

Stewart, D. D., M. D. Tests for Serum Albumen in the Urine. Pp. 19.—Non-albuminous Nephritis. Pp. 27.

Stokes, Anson Phelps. Joint-Metallism. New York: G. P. Putnam's Sons. Pp. 121.

Thompson, A. H. The Origin and Evolution of the Human Face and the Descent of Facial Expression. Pp. 20.

Trelease, William, St. Louis. Leitneria Floridana. Pp. 26, with 14 Plates.

University of the State of New York. Secretary's Report. Albany. Pp. 324. 35 cents.

Ward, H. Marshall. Action of Light on Bacteria and Fungi. Pp. 21.

Ward, Lester F., Washington. The Cretaceous Rim of the Black Hills. Pp. 16.—Neo-Darwinism and Neo-Lamarckism. Pp. 71.—Principes et Méthodes d'Étude de Corrélation géologique au Moyen des Plantes fossiles (Methods of Study of Geological Correlation by Means of Fossil Plants). Pp. 10.

"Wheelbarrow." Articles and Discussions on the Labor Question. Pp. 303. $1.

Wilkins, W. H., and Vivian, Herbert. The Green Bay Tree. New York: J. Selwin Tait & Sons. Pp. 389. 50 cents.

Wright, Mabel Osgood. The Friendship of Nature. Pp. 238. 75 cents.

POPULAR MISCELLANY.

Prof. William Dwight Whitney.—Prof. William Dwight Whitney, of Yale College, the foremost and greatest American philologist, died June 7th, in the sixty-eighth year of his age. He was born at Northampton, Mass., in 1827; was graduated from Williams College in 1845; after spending three years in the Northampton Bank, he went to Lake Superior in 1849 as an assistant in botany and ornithology in the United States Geological Survey. Having begun the study of Sanskrit, he continued it at Yale College, under Prof. Salisbury, for one year after his return from this work. He then studied in Germany, under Prof. Weber, of Berlin, and Prof. Roth, of Tübingen. Before he was thirty years of age he had edited, with Prof. Roth, the Atharda Veda, and had become Professor of Sanskrit in Yale College. He prepared a series of German text-books which have sustained an excellent reputation, and continued the publication of Sanskrit books in rapid succession, crowning the series with a Sanskrit grammar in English and German, and a book on the Roots, Verb Forms, and Primary Derivatives of the Sanskrit Language, which appeared in 1879. These works, says the Nation, "are based, not on the dicta of predecessors, but upon actual observation of the facts of the language, which are subjected to masterly classification and vigorously scientific induction." He wrote frequent and valuable essays on Hindu astronomy, phonetics, comparative grammar, and mythology; Oriental religions and literature, and the origin and nature of languages; and delivered lectures at the Smithsonian and Lowell Institutions, out of which grew the volume on the Life and Growth of Language of the International Scientific Series and his book on Language and the Study of Language, which have been widely translated. Other essays were embodied in the book, Oriental and Linguistic Studies. He was an important contributor to the Sanskrit-German Lexicon published by the Imperial Academy of Russia, 1852–'75; was a member and officer of the American Oriental Society for fifty-one years, and its president after 1884; was first president of the American Philological Association and a frequent contributor to its Transactions and Proceedings; was editor-in-chief of the Century Dictionary, and was a member of numerous learned societies abroad. A biographical sketch of Prof. Whitney was given, with portrait, in The Popular Science Monthly for May, 1879 (Vol. XV).

Women and Education in the South.—A valuable circular published by the United States Bureau of Education is that on Southern Women in the Recent Educational Movement in the South, which has been prepared by the Rev. A. D. Mayo, and embodies a review of what he has seen and learned during twelve years that he has been engaged in the service of education in the South, in which he has come in contact with every variety of school, both races, and all classes. The essay presents three main divisions, relating respectively to Southern schools for the education of girls; the work of Northern and Southern women in the superior schools for colored youth; and the common school; in all of which departments the women of the South are becoming every year more broadly and vitally interested. To the principal paper are added in an appendix several essays, originally presented as lectures or magazine articles, bearing on the subject of education in the South.

Cause of the Migration of Birds.—Concerning the reason of birds migrating, Canon Tristram observed in the British Association that observation has brought to light many facts which seem to increase the difficulties of a satisfactory answei to the question. The autumnal retreat from the breeding quarters might be explained by a want of sufficient sustenance as winter approaches in the higher latitudes, but this will not account for the return migration in spring, since there is no perceptible diminution of

supplies in the winter quarters. The northward movement of all the others must be through some impulse not yet ascertained. In many other instances it is not dependent on the weather at the moment. This is especially the case with sea birds. Prof. Newton observes they can be trusted as the almanac itself. Foul weather or fair, heat or cold, the puffins—*Fratercula arctica*—repair to some of their stations punctually on a given day, as if their movements were regulated by clockwork. In like manner, whether the summer be cold or hot, the swifts leave their summer home in England about the first week in August, only occasional stragglers ever being seen after that date. To say that migration is performed by instinct is no explanation of the marvelvelous faculty; it is an evasion of the difficulty. The sense of sight can not guide birds which travel by night, or span oceans or continents in a single flight. In noticing all the phenomena of migration there yet remains a vast untilled region for the field naturalist. What Prof. Newton terms the sense of direction, unconsciously exercised, is the nearest approach yet made to a solution of the problem. He remarks how vastly the sense of direction varies in human beings, contrasting its absence in the dwellers in towns compared with the power of the shepherd and the countryman, and, infinitely more, with the power of the savage or the Arab.

Chemical Constitution and Color.—A curious side light, says Prof. James Emerson Reynolds, seems to be thrown on the nature of the elements by the chemico-physical discussion of the connection existing between the constitution of certain organic compounds and the colors they exhibit. We may take it as an established fact that a relation exists between the power which a dissolved chemical compound possesses of producing the color impression within our comparatively small visual range, and the particular mode of grouping of its constituent radicals in its molecule. Further, the reality of this connection will be most freely admitted in the class of aromatic compounds—that is, in derivatives of benzene, whose constituents are so closely linked together as to exhibit *quasi*-elemental persistence. If, then, the possession of what we call color by a compound be connected with its constitution, may we not infer that "elements" which exhibit distinct color, such as gold and copper, in thin layers and in their soluble compounds, are at least complexes analogous to definitely decomposable substances? This inference, while legitimate as it stands, would obviously acquire strength if we could show that anything like isomerism exists among the elements; for identity of atomic weight of any two chemically distinct elements must, by all analogy with compounds, imply dissimilarity in constitution, and therefore definite structure, independently of any argument derived from color. Now, nickel and cobalt are perfectly distinct elements, as we all know, but, so far as existing evidence goes, the observed differences in their atomic weights (nickel, 58·6; cobalt, 58·7) are so small as to be within the range of the experimental errors to which the determinations were liable. Here, then, we seem to have the required example of something like isomerism among elements, and consequently some evidence that these substances are complexes of different orders; but in the cases of cobalt and nickel we also know that in transparent solutions of their salts, if not in thin layers of the metals themselves, they exhibit strong and distinct colors—compare the beautiful rosy tint of cobalt sulphate with the brilliant green of the corresponding salt of nickel. Therefore, in exhibiting characteristically different colors, these substances afford us some further evidence of structural differences between the matter of which they consist, and support the conclusion to which their apparent identity in atomic weight would lead us. By means of such side lights we may gradually acquire some idea of the nature of the elements, even if we are unable to get any clew to their origin other than such as may be found in Crookes's interesting speculations.

The Camphor Tree.—While camphor was formerly produced in Sumatra, Borneo, and other parts of the East Indies, all now known to the trade comes from Japan and Formosa. The camphor tree is a large evergreen of symmetrical proportions, somewhat resembling a linden. It bears a white flower which ripens into a red berry. Some of the

trees are fifteen feet in diameter and live to a great age. A group of trees in the province of Toosa, about a century old, are estimated to be equivalent to about forty thousand pounds of crude camphor. The camphor is extracted from chips taken from the roots or from the stem near the root, the wood yielding about five per cent of camphor, and the root a larger proportion. The annual export of Japan camphor averages about five million pounds. The forests in Japan owned by the people are now almost denuded of timber, but the Government still possesses large woods of camphor trees, which, it is estimated, will maintain a full average supply of the gum for the next twenty-five years. Plantations of young trees are also making and well taken care of; and although camphor has not hitherto been extracted from trees less than seventy or eighty years old, it is expected that under the present intelligent management equally good results may be realized in twenty-five or thirty years. The Japanese Department of Forests, which has the control of these woods, is under good management.

Constitution of the Ether.—Assuming that the elastic solid theory of the ether has failed, Mr. R. T. Glazebrook thinks that the properties of the ether which would lead to the equations that represent the laws of the transmission of light, may be found in the labile ether of Lord Kelvin. This is an elastic solid, or *quasi* solid incapable of transmitting normal waves. Such a medium would collapse unless of infinite extent, or else fixed at its boundaries. A soap bubble affords in two dimensions an illustration of it, the tension being independent of its dimensions. Waves of displacement parallel to the surface of the film would not be transmitted. But such a film in consequence of its tension has an apparent rigidity for displacements normal to its surface; it can transmit transverse waves with a velocity which depends on the tension. Now the labile ether is a medium which has, in three dimensions, characteristics resembling those of the two dimensional film. Given such a medium—and there is nothing impossible in its conception—and the main phenomena of light follow as a necessary consequence. Lord Kelvin, again, has shown us how such a medium might be made up of molecules, having rotation in such a way that it could not be distinguished from an ordinary fluid in respect to any rotational motion; it would, however, resist rotational movements with a force proportional to the twist, just the force required. The medium has no real rigidity, but only a *quasi* rigidity conferred on it by its rotational motion. The actual periodic displacements of such a medium may constitute light. We may claim, then, with some confidence, to have a mechanical theory of light. But nowadays the ether has other functions to perform, and there is another theory to consider, which at present holds the field. Maxwell's equations of the electro-magnetic field are practically identical with those of the *quasi*-labile ether. The symbols which occur can have an electro-magnetic meaning; we speak of permeability and inductive capacity instead of rigidity and density, and take as our variables the electric or magnetic displacements instead of the actual displacement of the rotation. Still, such a thing is not mechanical, and we have no satisfactory mechanical theory of the electro-magnetic field. But the theory of the *quasi*-labile ether may be applied, and gives two analogies according as we regard the density of the medium to be analogous to electrostatic inductive capacity or to magnetic permeability.

Explorations in Thibet.—In a paper on Recent Explorations in Thibet, Mr. E. Delmar Morgan said in the British Association that the discoveries made by travelers, beginning with the Schlagintweit brothers and ending with Dr. Thorold's recent journey, had opened out new fields of research in hitherto inaccessible parts. They had determined the continuity of the Kuen Luen mountain system through twenty degrees of longitude, and made known the direction and structure of the principal chains. They had shown the lacustrine character of the central plateaus, and traced almost to their sources some of the mightiest rivers of Asia. They had thrown light on the climatic conditions of these lofty deserts, and seen an abundance of animal life on them. Their researches had proved the existence, in former times, of a line of flourishing oases along the northern foot of the Kuen Luen,

by which the Chinese silk trade passed in the middle ages, and had brought to light the leading gold fields of northern Thibet.

Weather and the Mind.—The psychology of the weather is suggested by Dr. T. D. Crothers as a promising subject for study. He says, in Science: "Very few persons recognize the sources of error that come directly from atmospheric conditions on experimenters and observers and others. In my own case I have been amazed at the faulty deductions and misconceptions which were made in damp, foggy weather, or on days in which the air was charged with electricity and thunderstorms were impending. What seemed clear to me at these times appeared later to be filled with error. An actuary in a large insurance company is obliged to stop work at such times, finding that he makes so many mistakes which he is only conscious of later that his work is useless. In a large factory from ten to twenty per cent less work is brought out on damp days and days of threatening storm. The superintendent, in receiving orders to be delivered at a certain time, takes this factor into calculation. There is a theory among many persons in the fire-insurance business that in states of depressing atmosphere greater carelessness exists and more fires follow. Engineers of railway locomotives have some curious theories of trouble, accidents, and increased dangers in such periods, attributing them to the machinery." Dr. Crothers adds that the conviction prevails among many active brain workers in his circle that some very powerful forces coming from what is popularly called the weather control the work and its success of each one.

Seeking Perfection.—The Rev. J. A. Wylie, describing his journey through central Manchuria, speaks of a charming place, the Lao Te Ling, near Ta Shin Ho, where, at the summit of a hill, "there are several fine temples, including one, a large Buddhist temple, in course of erection; and in connection with this there is an interesting story. In a little house with eight feet by six feet of accommodation, two thirds of which is occupied by a small Kang, there lives a Buddhist priest. His head is not close-shaven, as the heads of other Buddhist priests are, for since taking up his residence in these quarters, or rather in this sentry box, he has allowed his locks to grow. For four years has he already been here, and another three years at least remain for him to stay. He is seeking to attain perfection, and he must finish what he has begun. Not until the temple is finished building will he be at liberty to leave his post. The little door of this priest's domicile is sealed up, so he never even steps out into the open air; there is only a small opening in the door or window for an attendant to hand in his meals. These meals are scanty and few; only one meal a day at noon. He drinks great quantities of tea, however; he seems to put no limit to his indulgence in that beverage. In sleep he does not stretch himself out; in fact, he never lies down, he only half reclines, and, asleep or awake, he constantly keeps pulling away at a rope which connects with the temple bell, which must never cease to ring. Travelers passing at all hours may hear the bell sounding; this is part of his work of merit. While I was with him, even although we spoke in such a way that everything else might be forgotten, he did not forget to pull the rope. How, during sleep, he manages is to me the mystery. He had heard long ago of the Christian religion; some books I offered him he refused, on the ground that before he had purified himself by completing his task it would be sacrilege to touch these books. When I pressed him he accepted them, however. How earnest must this man be when he thus denies himself! Still it is merit, and merit for himself, that he is endeavoring to attain."

Coal-dust Explosions.—A strong confirmation of the theory that coal dust is a frequent cause of explosions in coal mines is given by the experiments made in the White Moss Colliery, Skelmersdale, and recorded by Mr. Henry Hall, inspector of mines. It appears from them that the flame from a blowing-out gunpowder shot in the presence of dry coal dust is always found to ignite more or less such dust and to increase the burning and charring effects of the shot. When a large flame, such as that of a blowing-out gunpowder shot, or the flame from the ignition of a small quantity of fire damp,

traverses an atmosphere containing a very moderate quantity of dry coal dust, the dusty atmosphere will explode with great violence, and the explosion will continue and pass throughout any length of such atmosphere, its violence and force increasing as it progresses. The coal dust from several seams in certain different districts is almost as sensitive to explosion as gunpowder itself, the degree of sensitiveness increasing in proportion to its high quality and freedom from impurities. In mines which are briskly ventilated there is a greater probability of explosion, while in such cases it is generally more severe. One of the most important results of the experiments made has been to demonstrate that certain high "explosives" (roburite, ammonite, etc.) are incapable of igniting or exploding coal dust. Mr. Hall, in face of these facts, is therefore led to urge the total abolition of gunpowder from coal mines for blasting purposes and the substitution of certain "high explosives"—precautionary measures which many large firms have already adopted. Apart from the danger of using gunpowder arising from the ease with which it starts a dust explosion, it appears that in mere handling alone four hundred lives have been sacrificed during the last twenty years, while the loss of life from explosions caused by gunpowder during the same time has been at least one half of the total loss—viz., 4,098 persons. With regard to preventive measures, every possible effort, it is recommended, should be made, either by watering the dry dust or removing it to avoid accumulation, so that any accidental ignition of fire damp may be limited in its effects and prevented from developing into a sweeping explosion through the agency of dust.

Birds of Michigan.—The Bird Fauna of Michigan, as described by Mr. A. J. Cook in a bulletin of the State Agricultural Experiment Station, being protected by the Great Lakes nearly surrounding the State, is very interesting. As is shown by Dr. C. Hart Merriam's colored map, it embraces representatives of three distinct faunas—viz., the boreal in the north, which includes the northern peninsula and the northern part of the southern peninsula; the transition, which occupies nearly all the southern peninsula, and reaches slightly into Indiana and Ohio; and the upper Sonoran, which, though mostly to the south of Michigan, reaches into the southeastern and southwestern corners of the State. There are met in Michigan many birds peculiar to the far north, and others that dwell for the most part in the States and countries to the south, even reaching to and beyond the Gulf. The first are illustrated in the Bohemian waxwing, the spruce partridge, the Canada jay, and the pine grosbeak; and the summer redbird, the mocking bird, and the cardinal redbird illustrate the second group. The large lakes attract many birds that are usually maritime, like the gulls and the terns; while in southern Michigan, with its prairies and woodlands, both widely distributed, are found the prairie fauna, as illustrated in the pinnated grouse, and those birds which are most at home in the forests of wooded areas, like most of the thrushes and the warblers.

The Future Work of the American University.—Addressing the Pennsylvania State Board of Agriculture on the Progress and Practical Value of Agricultural Science, Dr. Peter Collier gave a prominent place in illustration to the work that has been done in the analysis of fertilizers, whereby frauds have been exposed, and farmers have been pecuniarily benefited by the cheapening of fertilizing materials and the assurance of increased and improved crops. A further illustration is found in the progress and practical applications of bacteriology—a word which, together with bacteria, does not occur in the standard dictionaries of 1868—by means of which the causes and cures of the most serious maladies that affect crops have been discovered and brought within the reach of all, and such operations as the making of butter and cheese are facilitated. One would not have imagined a short time ago that physics and physiology were the sisters of psychology, or that ethics should consort with economics and sociology in the same laboratory, or that a professor of institutional history should commend to his pupils biology as a minor subject. Yet all these things have really happened. Indeed, only since Darwin and Spencer has it been possible to discover the essential kinship of the various branches of knowledge. Projecting

the future of the American university, the author assumes that it must become the representative of dynamic culture. The university should have much to do with social reforms, political regeneration, and correction of errors in the treatment of criminals. Social and political reform will be impossible without moral regeneration, in which, as the work must begin with the individual, the university has a noble part to perform. "The fact is, the American people need a tonic of the most active kind. Partly as a result of the spoils system and partly in consequence of the unnatural industrial and political conditions produced by the civil war, we have been brought to a very low plane of public morality. 'It is a familiar fact,' says Herbert Spencer, 'that the corporate conscience is ever inferior to the individual conscience.' Indeed, it seems to me that a nation is in evil straits when the standard of public morality is very much lower than the standard of private morality, and that is precisely the case with the people of the United States. Never, perhaps, has there been a greater disparity between political and private ethics. A double system of morality is a dangerous possession for any nation. Our ideal of public conduct must approximate more nearly to our ideal of private conduct if we would ever attain the best in the higher life."

Remaking our Boys.—"Boys, as they are made," as contemplated by F. H. Briggs, of the State Industrial School, Rochester, in an address concerning them, are not the boys who have home privileges and careful, competent home training, but the boys of the slums, and of the poor and the degraded. The question, How to remake them? is one that the public school should have an important part in answering. For the child-boy, in the author's view, the kindergarten should be substituted for the home and street during the day, and one should be established, where all will be treated with equal consideration, in every locality where the poor abound. "The kindergarten gives the child the mental, physical, and moral exercise that it needs. . . . But what about the boys who are beyond the kindergarten age now, and about the boys who have passed through the kindergartens? Put them into manual training schools. . . . What should be the instruction in these schools? That which in a natural way develops the physical, mental, and moral faculties. The workshop should form an inseparable concomitant of every school. Children delight in doing. This is why the kindergarten is so effective as an educational agent." Our school for the boy should have drawing for its corner stone; and modeling should accompany it, that by the test of actual contact the correctness of the perceptions of size and form may be tested, and the love of the beautiful more fully gratified. Then the use of woodworking tools—the one thing that a boy always delights in. "It helps a boy to find out what square means. When he can saw to the line every time, he has a greater respect for truth. When he habitually becomes exact in the use of tools the great battle is won. Your skilled mechanic is not usually a liar. His respect for exactness makes him hard to the line in his speech. These three, then, drawing, modeling, and woodworking in its various forms, should form the foundation upon which our remaking structure should rest." And they should add development and symmetry to the whole. "These things lie at the very basis of all handicraft. They enable one trained in them to see things in new ways; to see their parts, their forms, their beauties; in fact, as training for the perceptive and conceptive faculties they have no equal. No scheme of education is complete that leaves music out." Nature has a warm place in every child's heart. It is ever presenting some new form for contemplation; "and as bud, leaf, flower, and fruit appear they challenge the child's attention and invite study. . . . Why has Nature been so long a closed book to the masses? Why is so much that is beautiful and ennobling denied to the famishing souls of little children? Why should natural history and science wait for the high-school or college course that the great mass of people never reach?"

Town Refuse as Fuel.—Experiments in seeking to utilize the refuse of towns as fuel have been carried so far that a plant, known as the Livèt plant, has been set up in Halifax, England, with which it is intended to supply electric energy. The successful

working of the Livèt furnace appears to depend upon the peculiar construction of its flues, which are so built as to utilize the effect of the decreasing volume of the gases of combustion traveling toward the chimney, so promoting a high velocity to the air passing through the furnace bars and producing rapid combustion with intense heat. At the same time, the effect of this peculiarity of construction is to cause the gases themselves to move slowly through the flues, so that they may part with their useful heat before escaping into the atmosphere. The force of draught at the furnace is such that a high and constant temperature is obtained and efficiency of combustion insured, while all unpleasant odors inherent in town garbage are destroyed. As an example of the heat economy effected, it is said that whereas in previous generators the best results ever obtained have been three quarters of a pound of water evaporated on the combustion of one pound of refuse, in the Livèt generator over three pounds of water are evaporated into steam for every pound of refuse consumed, in spite of the fact that it is frequently known to contain twenty per cent of moisture. The temperature of the gases just before entering the chimney is stated to be from 300° to 400° Fahr. lower than hitherto obtained. The progression of the gases is partially arrested at both ends of each flue for the purpose of permitting them to deposit the contained light dust in suitable expansion chambers or pits which can be cleaned out when desirable. This arrangement serves to overcome the objectionable dust, which in ordinary "destructors" tends to choke the flues and impregnate the air of the surrounding districts.

Uses of Drinks.—In discussing the question whether Australia will become a wine-drinking country, Dr. Murray Gibbs pointed out that different nations had always, from time immemorial, selected certain beverages as national drinks, and that the fact that the fruit, leaf, or grain supplying the essential principle of the drink was not always indigenous to the national soil was itself a proof that convenience was not the only factor indicating the choice. Many continental nations drink, of course, the wine of their particular district, and for centuries the Englishman's beer was made from the Englishman's barley. On the other hand, the universal vogue of drinking decoctions made from the Eastern shrubs tea and coffee shows that the popularity of a beverage has no geographical limits. The character of the drink adopted as national must always be largely dictated by the character of the soil and food, and this, in turn, is dependent upon the climate of the country. Sir William Roberts has said that all beverages, alcoholic or non-alcoholic, conduce to one of two conditions—retardation of the digestive process or excitation of the nervous system. The harsher climates require the stronger foods, and these—inasmuch as time is necessary for their proper assimilation—call for checks upon a too rapid and so incomplete digestion. Chief among these are the vegetable acids contained in wine, and the sedative properties of tea and coffee.

Occupations to awaken Dormant Faculties.—In a paper on Industrial Training in Reformatory Institutions (published by C. W. Bardeen, Syracuse, N. Y.) Mr. F. M. Briggs, of the State Industrial School, relates a few incidents of cases in which mental powers, before dormant, were awakened by setting pupils at work for which they had a taste. "There are boys in the State Industrial School at the present time," the author says, "whose interest we could not arouse in the common schools. Some were naturally so weak mentally that, after weeks of conscientious work on the part of the teacher, they were not able to repeat from memory a four-verse stanza of a poem for children. Others would not apply themselves sufficiently long to learn anything. Some of these boys were placed in the clay-modeling and wood-carving shop. The boys who had been regarded as almost idiots soon began to show improvement. The boys who had been especially troublesome elsewhere, in the clay work ceased to be annoying. When a boy begins work with clay, he seems to feel himself in the unity of things and he becomes happy accordingly; and, as he sees the formless clay take shape beneath his touch, a sense of power is born within him which arouses and quickens him." A boy who had been cruel, cunning, and vicious, presenting no point for reaching his nature, one day in the wood-working shop

asked his teacher to look at a molding board he had made. "The old spirit seemed to be gone as he showed me the result of his handiwork; unconsciously he had found the secret of power." Another boy, regarded as hardly more than an idiot, had been gaining in his shop work, with his eye taking new brightness and his face clearing; and his school work showed the effect of the shop training. Another boy, a persistent offender in shop and school, expressed a desire, when decorating was introduced, to do work of that kind. The request was granted, and "his first effort showed his ability, and a new manhood asserted itself within him."

Beginnings of Mountain Climbing.—The glaciers of the Alps began to attract the attention of scientific men toward the end of the seventeenth century, but travelers making the grand tour considered mountains hideous. It was not, says Mr. W. M. Conway, till the dawn of romanticism, a hundred years later, that the beauty of mountains began to be recognized. The first snow mountains to be climbed were the Titlis in 1739. Pococke and Windham's visit to the Chamounix followed in 1741, and with that the modern epoch of Alpine exploration may be said to have begun. In 1775 an attempt was made to reach the summit of Mont Blanc. This was repeated in several subsequent years, till in 1786 Jacques Balmat and Michel Paccard were successful. De Saussure's famous ascent was made in 1787. During the next half century the prejudice against mountains and dread of them were gradually dissolved. The Jungfrau was climbed in 1811, the Finsteraarhorn in 1812, and other peaks followed. It was not till after 1850 that systematic Alpine climbing could be said to have been introduced. The present Mr. Justice Willis's ascent of the Wetterhorn in 1854 was usually recognized as the first important "sporting" climb. From that time forward the exploration of the Alps advanced rapidly. Monte Rosa was climbed in 1855, Mont Blanc without guides and by a new road in 1856. In 1859 the Alpine Club was founded in London, and the example thus set was shortly afterward followed by foreign mountaineers. Thenceforward the exploration of the Alps advanced rapidly, and it might now be regarded as fairly complete, so far as the main groups are concerned.

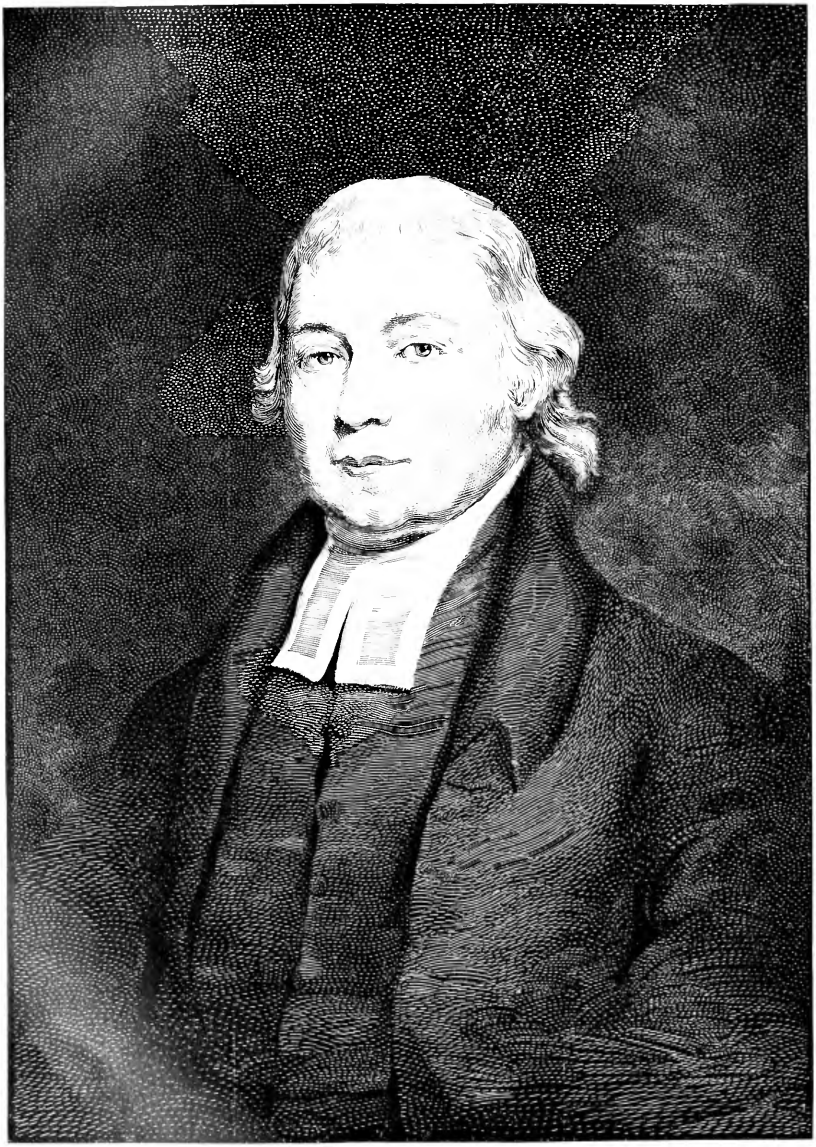
NOTES.

The summer meeting of the Northwestern Electrical Association was to be held in St. Paul, Minn., July 18th, 19th, and 20th. A larger number of attendants was expected than were present at the last meeting, including representatives from Illinois, Iowa, Michigan, Wisconsin, and North and South Dakota. An excellent programme was prepared, and speakers were invited from among the most expert representatives of the profession.

The essential oils were held in high esteem by the ancients, but lately seem to have been forgotten in the multitude of new discoveries. The power of many of them to destroy bacteria has, however, been demonstrated anew by M. Chamberland, M. Cadéac, and M. Meunier, and M. Blaizot and M. Caldagues have found in them bactericidal powers even greater than they had been supposed to possess. The essences found by these gentlemen to be most active are those of cinnamon, lavender, marjoram, cloves, geranium, vervain, and tuberose. The simple exposition of their vapors is sufficient to destroy in an hour such microbes as those of pus and cholera, and six minutes' exposure effects a manifest attenuation of their activity.

The method of purification by distillation in a vacuum, which has hitherto been little employed, except with mercury, has been applied by Prof. G. W. Kahlbaum, of Basle, with great success to potassium, sodium, selenium, tellurium, cadmium, magnesium, bismuth, and thallium, while the experiments with zinc and manganese have so far been unsatisfactory. Judging by spectrum analysis, an extreme degree of purity was obtained. Thus, thirty-five ines disappeared from the spectrum of tellurium, showing, the author believes, the absence of substances which modify the spectrum of the purest metal obtainable by other processes.

Two living German princes have distinguished themselves by becoming practicing physicians—Duke Karl Theodor, of the royal house of Bavaria, having completed a course of study, has made a specialty of eye diseases as they occur among the poor, and in April, 1893, successfully performed his two thousandth operation for cataract. Prince Louis Ferdinand, his cousin, besides being engaged in practice, works in the laboratory, and has recently made the etiology and pathology of pleurisy objects of special clinical and bacteriological studies. He has lately published a monograph concerning twenty-three patients suffering from pleuritis who came under his observation.



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STUDIES OF CHILDHOOD.

II.—THE IMAGINATIVE SIDE OF PLAY.

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CHILDREN'S play has been studied under different aspects. One of the most attractive of these is its imaginativeness. All play is to some extent fanciful—that is, inspired and vitalized by fantasy; and the element of fancifulness is especially rich and varied in the pastimes of the small people of the nursery.

Viewed on this side, child play may be described as the working out into actual visible shape of an inner fancy. In many cases, no doubt, the actual surroundings may supply the starting point; the child, for example, sees the sand, the shingle, and shells, and says, Let us play keeping a shop. Yet this suggestion by something present is accidental. The root impulse of play is to realize a bright, pretty idea; hence its close kinship with art as a whole. This image is the dominating force; it is for the time a veritable *idée fixe*, and everything has to accommodate itself to this. Since the image has to be acted out, it comes into collision with the actual surroundings. Here is the child's opportunity. The carpet is instantly mapped out into two hostile territories; the sofa-head becomes a horse, a coach, a ship, or what not, to suit the exigency of the play.

This stronger movement and wider range of childish imagination in play is explained by the characteristics and fundamental impulse of play—the desire to be something, to act a part. The child adventurer, as he personates Robinson Crusoe or other hero, steps out of his every-day self and so out of his every-day world.

In realizing his part he virtually transforms his surroundings, since they take on the look and the meaning which the part assigns to them. This is prettily illustrated in one of Mr. R. L. Stevenson's child-songs, The Land of Counterpane, in which a sick child describes the various transformations of the bed scene:

> "And sometimes for an hour or so
> I watched my leaden soldiers go,
> With different uniforms and drills,
> Among the bedclothes through the hills.
>
> "And sometimes sent my ships in fleets,
> All up and down among the sheets;
> Or brought my trees and houses out,
> And planted cities all about."

Who can say to how many and what strangely play purposes that stolid, unyielding-looking object a sofa-head has been turned by the ingenuity of the childish brain?

The impulse to act a part meets us very early and grows out of the imitative instinct. The very infant, if it finds an empty cup to hand, will proceed to drink out of it.* Similarly, a boy of two will put the stem of his father's pipe into or, if more cautious, near his mouth, and make believe that he is smoking. A little boy not yet two years old would spend a whole wet afternoon "painting" the furniture with a dry end of a bit of rope. In such cases it is evident the playing may start from a suggestion supplied by the sight of an object. There is no need to suppose that in this simple imitative play the children consciously act a part. It is surely to misunderstand the essence of play to speak of it as a fully conscious process of imitative acting.† A child is one creature when it is truly at play, another when it is bent on astonishing or amusing you. It seems sufficient to say that when at play it is possessed of an idea and is working this out into visible action. Your notice, even your laughter, if kind enough, may bring in a new element of enjoyment, for, as we all know, children are disposed to be little actors in the full sense, and to aim at producing an impression. Yet your intrusion will be at least just as likely to destroy the pleasure in so far as it is that of pure childish pastime; for the play instinct comes out most distinctly, perhaps, when a child is alone, or at least self-absorbed, and this suggests that the instinct springs out of the deepest and least sophisticated part of its nature.

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* Of course, as Preyer suggests, this drinking from an empty cup may at first be due to a want of discriminative perception.

† M. Compayré seems to go too far in this direction when he talks of the child's play with its doll as a charming comedy of maternity. (L'Evolution intellectuelle et morale de l'Enfant, p. 274.)

The essence of play is the realizing of an imaginary situation or action; it is thus in a sense dramatic; only that the child's drama, like M. Jourdain's prose, is unconscious. In this impulse to be something, the actual external surroundings play a greater or less part according to the needs of the player. Sometimes there is scarcely any adjustment of the actual objects and scene; the child plays out its action with purely imaginary surroundings, including companions or playmates. Thus one mother writes of her boy, aged two years and a half: "He amuses himself by pretending things. He will fetch an imaginary cake from a corner, rake together imaginary grass, or fight a battle with imaginary soldiers." As a recent little work shows,* some children have adopted permanently an invisible playmate. In such vivid realization the utmost interference with actual surroundings that is needed is change of place. Here is a pretty example of this simple imaginative play. A child of twenty months, who was accustomed to meet a *bonne* and child in the Jardin du Luxembourg, suddenly leaves the family living room, pronouncing indifferently well the names "Luxembourg," "bonne," and "enfant." He goes into the next room, pretends to say "good day" to his two outdoor acquaintances, and then returns and narrates what he has been doing.† Here the simple act of passing into an adjoining room was enough to secure the needed realization of the encounter in the garden. The movement into the next room is suggestive. Primarily it meant, no doubt, that it was the child's way of realizing the out-of-door walk; yet I suspect that there was another motive at work. Children love to enact their little play-scenes in some remote spot, withdrawn from notice, where imagination suffers no let from the intrusion of mother, nurse, or other member of the real environment. How many a thrilling, exciting play has been carried out in a corner, especially if it be dark, or, better still, screened off! The fascination of curtained spaces, as those behind the window curtains, under the table with the tablecloth hanging low, will be fresh in the memory of all who can recall their childhood.

A step toward a more realistic kind of play-action, in which, as in the modern theater, imagination is propped up by strong scenic effects, is taken when a scene is constructed, the chairs and sofa turned into ships, carriages, a railway train, and so forth.

Yet, after all, the scene is but a very subordinate part of this infantile play. Next to itself proudly enjoying the part of the rider, the soldier, the engine-driver, or what not, the child wants

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* The Invisible Playmate, by Canton. London, Isbister; pp. 33 and following.

† Egger, quoted by Compayré, L'Evolution intellectuelle et morale de l'Enfant, pp. 149, 150.

a living companion. Something alive there must be, or at least something to simulate life, if only a railway engine. And here we meet with what is perhaps the most interesting feature of childish play—the transmutation of the most meager and least promising things into complete living forms. I have already alluded to the sofa. How many forms of animal life, vigorous and untiring, from the patient donkey up to the untamed horse of the prairies, has this most inert-looking ridge served to image forth to quick boyish perception!

The introduction of these living things seems to illustrate the large compass of the child's realizing power. Mr. Ruskin speaks somewhere of "the perfection of childlike imagination, the power of making everything out of nothing. . . . The child," he adds, "does not make a pet of a mechanical mouse that runs about the floor. . . . The child falls in love with a quiet thing, with an ugly one—nay, it may be with one to us totally devoid of meaning. The *besoin de croire* precedes the *besoin d'aimer*."

The quotation brings us to the focus where the rays of childish imagination seem to converge, the transformation of toys.

The fact that children make living things out of their toy horses, dogs, and the rest is known to every observer of their ways. To the natural, unskeptical eye the boy on his rude-carved wooden "gee-gee," slashing the dull flanks with all a boy's glee, is realizing the joy of actual riding; is possessed for the moment with the glorious ideas that the stiff, least organic-looking of structures which he strides is a very horse.

The liveliness of this realizing imagination is seen in the extraordinary poverty and meagerness of the toys which to their happy possessors are wholly satisfying. Here is a pretty picture of child's play from a German writer:

"There sits a little charming master of three years before his small table, busied for a whole hour in a fanciful game with shells. He has three so-called snake-heads in his domain—a large one and two smaller ones; this means two calves and a cow. In a tiny tin dish the little farmer has put all kinds of petals—that is, the fodder for his numerous and fine cattle. When the play has lasted a time the fodder dish transforms itself into a heavy wagon with hay; the little shells now become little horses, and are put to the shaft to pull the terrible load." *

The doll takes a supreme place in this fancy-realm of play. It is human, and satisfies higher instincts and emotions. As a French poet says, the little girl

"Rêve le nom de mère en berçant sa poupée."

* Goltz, Buch der Kindheit, pp. 4, 5.

But the boy has his doll-love also, and is often hardly less faithful than the girl. Endless is the variety of *rôle* assigned to the doll as to the tiny shell in our just-quoted description of play. The doll is the all-important comrade in that *solitude à deux* of which the child, like the adult, is so fond. Mrs. Burnett, in her pleasant memoir of her childhood,* tells us that while sitting and holding her doll in the armchair of the parlor she would sail across enchanted seas to enchanted islands, meeting with all sorts of thrilling adventures. At another time, when she wanted to act an Indian chief, the doll just as obediently took up the part of squaw.

Very humanly, on the whole, is the little doll-lover wont to use her pet, even though, as George Sand reminds us, there come moments of rage and battering. A little boy of two and a half years asked his mother one day, "Will you give me all my picture books to show dolly? I don't know which he will like best." He then pointed to each in turn, and looked at the doll's face for the answer. He made believe that it selected one, and then gravely showed it all the pictures, saying, "Look here, dolly," and carefully explaining them. In this way does the child seek to bring his mute playmate into the closest intimacy with himself, sharing his life to the full. The same thing is touchingly illustrated in the fact that Laura Bridgman, when visited by Dickens in 1842, was found to have put a tiny band over her doll's eyes to match the band she herself had to wear. It is illustrated further in the fact that a child is apt to insist on dolly's being treated by others as courteously as himself, expecting them to say good night to it on saying good night to himself, and so forth.

Here, nobody can surely doubt, we have the clearest evidence of play illusion. The lively imagination endows the inert wooden thing with the warmth of life and love. How large a part is played here by the alchemist, fancy, is known to all observers of children's ways. The faith, the devotion, often seem to increase as the first meretricious charms, the warm tints of the cheek and the lips, the well-shaped nose, the dainty clothes, prematurely fade, and the lovely toy which once kept groups of hungry-looking children gazing long at the shop window is reduced to the naked essence of a doll. A child's constancy to its doll when thus stripped of exterior charms and degraded to the lowest social stratum of dolldom is one of the sweetest and most humorous things in child life.

And then, what rude, unpromising things are adopted as doll pets! Mrs. Burnett tells us she once saw a dirty mite sitting on

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* The One I knew the Best of All.

a step in a squalid London street, blissfully engaged in cuddling warmly a little bundle of hay tied round the middle by a string. Laura Bridgman made a "baby" of a man's large boot. In these cases, surely, the *besoin d'aimer* was little if any behind the *besoin de croire*.

Do any of us really understand this doll superstition? Writers with clear, long-reaching memory have tried to take us back to childhood, and restore to us for a moment the whole undisturbed trust, the perfect satisfaction of love which the child brings to its doll. Yet even the imaginative genius of a George Sand is hardly equal, perhaps, to the feat of resuscitating the buried companion of our early days and making it live once more before our eyes. The truth is, the doll illusion is one of the first to pass. There are, I believe, a few sentimental girls who make a point, when they attain the years of enlightenment, of saving their dolls from the general wreckage of toys. Yet I suspect that the pets, when thus retained, are valued more for the outside charm of pretty face and hair, and most of all of their lovely clothes, than for the inherent worth of the doll itself—of what we may call the doll soul, which informs it and gives it to the child its true beauty.

Yet, if we can not get inside the old doll superstition, we may study it from the outside, and draw a helpful comparison between it and other known forms of sweet credulity. And here we have the curious fact that the doll exists not only for the child but for the "Nature-man." Savages, Sir John Lubbock tells us,* like toys such as dolls, Noah's arks, etc. The same writer remarks that the doll is "a hybrid between the baby and the fetich, and that it exhibits the contradictory character of its parents." Perhaps the changes of mood toward the doll of which George Sand writes illustrate the alternating preponderance of the baby and the fetich aspect. But, as Sir John also remarks, this hybrid is singularly unintelligible to grown-up people, and it seems the part of modesty here to bow to one of Nature's mysteries.

The vivification of the doll is the outcome of the play impulse, and this, as we have seen, is an impulse to act out, to realize an idea in outward show. The absorption in the idea and its outward expression serves to blot out the incongruities of scene and actors which you or I, a cold observer, would note.

How complete this play illusion may become here can be seen in more ways than one. We perceive it in the child's jealous insistence that everything shall for the time pass over from the everyday world into the new fancy-created one. About the age of four, writes M. Egger of his boy, "Felix is playing at being coachman. Emile happens to return home at the moment. In

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* Origin of Civilization. Appendix, p. 521.

announcing his brother, Felix does not say, 'Emile is come'; he says, 'The brother of the coachman is come.'" * Pestalozzi's little boy, aged three years and a half, was one day playing at being butcher, when his mother called him by his usual diminutive, "Jacobli." He at once replied: "No, no; you should call me butcher now." †

The intensity of the imaginative realizing powers in play is seen, too, in the stickling for fidelity to the original in all playful reproduction, whether of scenes observed in everyday life or of what has been narrated. The same little boy who showed his picture books to dolly was, we are told, when two years and eight months old, fond of imagining that he was Priest, his grandmamma's coachman. "He drives his toy horse from the armchair as a carriage, getting down every minute to 'let the ladies out' or to 'go shopping.' The make-believe extends to his insisting on the reins being held while he gets down, and so forth." The same thing shows itself in acting out stories. The full enjoyment of the realization depends on the faithful reproduction, the suitable outward embodiment of the vivid detailed idea in the player's mind. A delightful example of boyish exactitude in acting out a story may be found in Mark Twain's picture of Tom Sawyer and Huckleberry Finn playing at being shipwrecked on a desert island.

The following anecdote bears another kind of testimony—a most winsome kind—to the reality of children's play: One day two sisters said to one another, "Let us play being sisters." This might well sound insane enough to hasty ears, but is it not really eloquent? To me it suggests that the girls felt they were not realizing their sisterhood, not enjoying all the possible sweets of it, as they wanted to do; perhaps there had been a quarrel and a supervening childish coolness, and they felt that the way to get this vivid sense of what they were or ought to be one to the another was by playing the part, enacting a scene in which they would come close to one another in intense conjoint activity.

But there is still another and some will think a more conclusive way of satisfying ourselves of the reality of the play illusion. The child finds himself confronted by the unbelieving adult, who may even be cruel enough to laugh at his play and his day dreamings; and this frosty aloofness, this unfeeling quizzing of their little doings, is apt to cut the sensitive little nerves to the quick. I have heard of children who will cry if a stranger suddenly enters the nursery when they are hard at play and shows himself unsympathetic and critical. But here is a story which

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* Quoted by Compayré, *op. cit.*, p. 150.

† De Guimps's Life of Pestalozzi (English translation), p. 41.

seems to me even more conclusive on the point: "I remember" (writes a lady) "that one of my children, when about four, was playing 'shops' with the baby. The elder one was shopman at the time when I came into the room and kissed her. She broke out into piteous sobs; I could not understand why. At last she sobbed out, 'Mother, you *never* kiss the man in the shop.' For the time being her game was spoiled." The mother's kiss, though sweet in itself, had here wrought a sudden disillusion.

It is only right to say that this same lady adds that her children varied considerably in this susceptibility to the play illusion, and that she feels sure her second child, who is less intelligent, would not have troubled about the kiss.

Play may produce not only the vivid imaginative realization at the time, but a sort of mild permanent illusion. Sometimes it is a toy horse, in one case communicated to me it was a funny-looking toy lion, more frequently it is the human effigy, the doll, which, as the result of successive acts of imaginative vivification, gets taken up into the relation of permanent companion and pet. Clusters of happy association envelop it, endowing it with a fixed vitality and character. A mother once asked her boy of two years and a half if his doll was a boy or a girl. He said at first, "A boy," but presently correcting himself added, "I think it is a baby." Here we have a challenging of the inner conviction by a question, a moment of reflection, and as a result of this, the unambiguous confession that the doll had its place in the living human family.

Here is a more stubborn exhibition on the part of another boy of this lasting faith in the plaything called out by others' skeptical attitude. "When" (writes a lady correspondent) "he was just over two years old, L—— began to speak of a favorite wooden horse (Dobbin) as if it was a real living creature. 'No tarpenter (carpenter) made Dobbin,' he would say; 'he is not wooden, but kin (skin) and bones, and Dod (God) made him.' If any one said 'it' in speaking of the horse his wrath was instantly aroused, and he would shout indignantly: 'It! You muttent tay *it*, you mut tay *he*.' He imagined the horse was possessed of every virtue, and it was strange to see what an influence this creature of his own imagination exercised over him. If there was anything L—— particularly wished not to do, his mother had only to say, 'Dobbin would like you to do this,' and it was done without a murmur."

There is another domain of childish activity closely bordering on that play where we may observe a like suffusion of the world of sense by imagination. I refer to pictures and artistic representations generally. If in the case of adults there is a half illusion, a kind of oneiratic trance condition, induced by a picture or

dramatic spectacle, in the case of the less instructed child the illusion is apt to become more complete. I have several striking stories about the effect of pictures on children's minds. A picture seems very much of a toy to a child. A baby of eight or nine months will talk to a picture as to a living thing; and something of this tendency to make a fetich of a drawing survives much later.

A quaint anecdote is recorded in a collection of children's thoughts recently published in America.* One day F——, a boy of four, called on a friend, Mrs. C——, when she had just received a picture, a scene in winter, in which persons were represented as going to church, some on foot and others in sleighs. . . . F—— wanted to know where they were going, and Mrs. C—— told him. The next day he came and noticed the picture, and looked at Mrs. C—— and then at the picture, and said, "Why, Mrs. C——, them people haven't got there yet, have they?" What, it may be asked, did the boy mean by his question? Did he in his vivid imaginative realization actually confuse the representation with the reality represented, after the manner of the sailors who, visiting a theater where the actors were representing a struggle of smugglers with a captain, took the performance to be a reality and rushed on the stage in order to protect the captain? There seems to be less excuse for confounding representation and reality in the case of the picture than in that of the stage. Perhaps, however, the boy F—— was less stupid than is here suggested. Did he, as the result of an intense realization of the scene pictured, excogitate the idea that the picture must at least represent something actual—that is to say, going on at the moment? Here is an opportunity for the mind quick to disentangle childish thought.

However this be, the vivid realization of pictures by children is a well-certified fact. Here is a story of a little boy, aged three years and some months: "His mother had gone to the sea and L—— (the child) was staying at his grandfather's. One day he was looking at a picture of a stormy sea, and on the sea was a little boat with an old man and a girl in it. He had heard the story of Grace Darling and her father, and at once decided that the picture represented them. After talking about them for some time his thoughts turned to his mother, and he began to imagine all sorts of things about her: 'And mamma is on de tea (sea) in a ickle (little) boat, and de waves are dashing over it, and (with great excitement) it will be turned over and mamma ill be drowned, and de master (one of the names for himself) will not be dere to tave (save) her!' By this time the big tears were rolling down

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* The Study of Children at the State Normal School at Worcester, Mass.

his cheeks, and he was in such an agony of grief that his grandmother had to take the picture from him and try to divert his thoughts."

Here, it is pretty evident, we have to do with a degree of illusion which equals if it does not surpass that of the most absorbing play. We must remember that a detailed pictorial representation, especially if it is colored, gives to the eye a full presentment of a scene and so favors a particularly clear and vivid imaginative realization. It is probable, too, that the abstract mode of representation in pictorial art, as compared, say, with that of the stage, hardly counts for the child's perception. Even the ordinary adult, innocent of artistic aims and methods, is wont, when gazing upon a painting, to lose all count of the picture as such, his consciousness being focused for the intense imaginative realization of its meaning.

I do not, of course, mean that all realization of form by the young mind is of this illusory intensity. One striking characteristic of children's fancy is to interpret rapidly the boldest hints of a representation of a familiar form, more especially that of man and of animals. All observers of imaginative children can testify as to the quickness with which they detect the semblance of a human or animal form in the irregular lines of a cracked ceiling, in the veining of marble, or in the lineal design of a carpet, not to speak of slight and imperfect pictorial sketches. They are apt, as already remarked, to show this imaginative facility with respect to the forms of letters. Here is an example: The pen of a little boy, well on in his fourth year, when tracing a letter L, happened to slip, so that the horizontal limb formed an angle upward, thus: . He instantly saw the resemblance to the bent knee of the human form, and said, "Oh, he's sitting down." Similarly, when he made an F turn the wrong way, and then put the correct form to the left, thus, F ꟻ, he exclaimed, "They're talking together." Here, it is to be presumed, illusion is less complete, fancy amusing itself, so to speak, with the form and making it suggestive and representative. And probably the same applies to some of the earliest and clumsiest of children's attempts to draw men and horses, and so forth; only that here we have to do with a pre-existing idea and an artistic intention to give outer embodiment to this idea—a circumstance which tends to make the process of imaginative realization steadier and more dominant.

I have here dealt with children's play and kindred forms of activity as the outcome of a strong bent to imaginative realization, to the vivid, half-illusory picturing out of things. At the same time it is to be noticed that, in the forms in which this imaginative impulse works itself out, we see a good deal more of the

child's mind; we see intelligence and, to some extent, also character. Thus, before there can be the faithful mimetic play of our little coachman, there must have been close observation and memory of what was observed. On the other hand, that most useful quality of intelligence which we call resource and invention comes out clearly in all the freer and more original sorts of play. Again, while all children are players—did not Victor Hugo rightly make the little body-starved and mind-starved Fantine conserve the play instinct?—they exhibit many and even profound differences of mind and character in their play. How unlike the girl's passive, dreamy play—as when sitting and holding her doll—to the more active boy's play, with its vigorous fightings, its arm-aching draggings of furniture! How different, again, the inchoate idealess play of a stupid child with the contents of a Noah's ark from the well-considered, finished, and varied play of a bright, intelligent child with the same material! Curious differences of taste, too, and even of moral instinct reflect themselves in the play of children. There is a quaint precocity of the practical instinct, the impulse to make one's self useful, in some children, which is apt to come out in their play. The little boy referred to above, who would spend a whole wet afternoon "painting" the furniture, must have had a decided bent toward useful work. Other children are no less quaintly precocious in the matter of morals, laying down commands on their dolls, punishing them for being naughty, and so forth—all with the appearance of a real and earnest conscientiousness.

While the forms of imaginative activity in play are thus selectively determined by individual aptitudes and dispositions, they will, of course, throughout remain dependent on the special experiences and fields of observation. Play is largely imitative of what has been experienced by the child, seen by him, or told him by others. The richer the surroundings, the fuller the sources of instruction, the more elaborate and various can the play representation become. Boys' play is often an imitation of the doings of their fathers and others—that is to say, when, as in the case of the farmer, the engineer, or the soldier, the paternal vocation lends itself to an interesting kind of play action. The sons of literary men do not, so far as I have heard, render their sires this flattering attention. Possibly, now that women's occupations also are getting differentiated, girls will be found to follow in their play the special lines of activity of their respective mothers.

Enough has probably been said to show how interesting a subject for study is offered us in children's play. Here, as has been well said, we seem to catch the child in his own world, acting out his own impulses without stimulus, guidance, or restraint from

others. Here, with something of the poet, the artist, of the serious man of business, too, yet being in truth none of these, he sets about creating his own world—a world which, like those we all create in our several fashions, bears on every feature the stamp of the creative mind.

THE HUMMING BIRDS OF CHOCORUA.

By FRANK BOLLES.

WHILE snow still sparkles in the frost furrows on Chocorua's peak, the first rubythroats appear in the warm meadows and forest glades at the south of the mountain. They love the flowers as others of their race love them, and when apple blossoms bless the air with perfume and visions of lovely color and form, the humming birds revel in the orchards of the North as their brothers delight in the rich flowers of the tropics. It is not, however, among flowers that the Chocorua rubythroats are happiest or most frequently seen. Were some one to ask me to find a humming bird quickly, it would make no difference what the age of the summer or what the hour of the day, I should turn my steps toward the forest, feeling certain that at the drinking fountains of the yellow-breasted woodpecker, the red-capped tapster, and loud-voiced toper of the birch wood, I should find the rubythroats sipping their favorite drink.

About the middle of April, and again nearly six months later, a mischievous and wary woodpecker migrates north and south across New England. The casual observer might take him to be a demure little downy, intent upon keeping the orchard free from insects, and if the sly migrant was ordinarily quick in placing a tree trunk between his black-and-white body and the observer his identity would not be detected. On April 17, 1892, I noticed one of these birds clinging to a smooth spot on the trunk of a shagbark which grew on a warm pasture hillside in sight of Bunker Hill and the golden dome of the Massachusetts State House. Watching him carefully for a moment, I saw that he was a yellow-breasted or sap-sucking woodpecker, perhaps one of my own Chocorua neighbors, and that he was quietly sipping the sweet sap of the shagbark which was flowing from several small holes in the bark, drilled, no doubt, that very morning by the traveler so serenely occupied. The sapsuckers reach northern New Hampshire before the snow has wholly melted in the woods. I have seen them at Chocorua, on May 1st, at work upon trees which they had evidently been tapping for fully a week. From this time until the last of September, perhaps even till the 7th or 8th of October, they spend the greater part of their time drilling small

holes in the bark of their favorite trees and in sipping from the sap fountains thus opened the life blood of the doomed trees. They do not range about through the forest tapping one tree here and another there, but they select one, two, perhaps three groups of trees well lighted and warmed by the sun, and make sap orchards of them, clinging to them many hours at a time, week after week, and returning to them, or others close at hand, year after year. Within a mile of my cottage at the foot of Chocorua there are half a dozen of these drinking places of the yellow-breasted woodpeckers, and each one of them is a focus for rubythroats. The one which I have known longest I discovered in 1887. It consists of a group of gray birches, springing from a single stump and expanding into fifteen distinct trunks. When I first saw it all the trees were living, and nearly all of them were yielding sap from the girdles of small drills which the woodpeckers had made in the trunks, about nine feet from the ground. In July, 1893, all but three of the trees were dead, and of the dead trunks all except two had been broken off by the wind at a point a few inches below the drills. The surviving trees had been tapped, and were in use by both sapsuckers and humming birds. During 1890, 1891, and 1892 the humming bird in attendance at this orchard was a male of noticeably strong character. There was no mistaking him for any chance visitor at the place. He spent all his time there, and repelled intruders with great vigor, flying violently at them, squeaking, humming as noisily as a swarm of bees, and returning to his favorite perch as soon as they had been put to flight. He often attacked the sapsuckers themselves, buzzed in their faces, and seemed little abashed when they turned upon him, as they sometimes did, and drove him from their midst. He also had a habit of squeaking spitefully when he was drinking from the sap wells, especially on his return from a bout with some other humming bird. Searching for him in July, 1893, I failed to find him, but discovered that in his place a pair of birds seemed to have established themselves. Of course, it is possible that my friend of previous years may have taken to himself a wife and have become mild-mannered in consequence, but I find it impossible to believe in this theory, so pronounced were the old male's temper and peculiar ways. The new male, for example, did not use the same twigs for perches, and he did not keep his head wagging from side to side as the old one did with a vigor and regularity which nothing but a pendulum ever equaled.

The new male, however, showed me a performance far more interesting in character than any of his petulant predecessor's, and one which establishes the Chocorua rubythroat as a musician and a dancer. One day, while this male was drinking at the sap fountains, a female arrived. The male greeted her with squeaks and

intense humming. She alighted on the tree near the drills, and the male then hurled himself through the air with amazing speed, describing a curve such as would be drawn by a violently swung pendulum attached to a cord fifteen or eighteen feet long. The female was at the lowest point of the arc described by her vehement admirer, and she sat perfectly motionless while he swung past her eight times. When he moved fastest—that is, when he approached and passed her—he produced in some unknown way a high, clear, sweet musical note, louder even than the humming which was incessant during his flight. In this first performance the male moved from north to south. A few minutes later he went through the dance a second time, describing a shorter curve and moving east and west. Still a third time, when the female had taken position in the midst of a few dense branches, the male faced her, and in a short arc, the plane of which was horizontal, flew back and forth before her. I had seen this performance once before, in July, 1890, at another orchard, and at that time I fancied that both birds took part in the flight, but in this case the birds were close above me as I lay among the ferns, and there was no difficulty in seeing clearly all that they did. During July, 1893, whenever I visited this orchard, which I call "No. 4," I found a male and a female rubythroat in attendance upon it.

In July and August, 1890, while watching sapsuckers at what I called orchards "No. 1" and "No. 2," I found that some woodpeckers adopted an entirely different method of dealing with humming birds from that practiced by others. At orchard No. 1 the woodpeckers drove away a humming bird with a marked display of anger whenever one showed itself near the large red maple which was being tapped. At orchard No. 2, on the contrary, the sapsuckers allowed the rubythroats to drink at drills a few inches from their own bills, and resented only marked impertinence on the part of their tiny visitors. At No. 1 scores of visits were paid by humming birds every day, but they reached the drills in a comparatively small number of instances. When they did gain them they drank long and deeply, often perching upon the bark and drinking while their nervous wings were motionless. At No. 2 it seemed impossible to estimate the number of humming birds in attendance. I went so far as to shoot a male and a female in order to feel certain that more than one pair of the tiny birds came to the drills. Nine minutes after my second crime a third humming bird was quietly drinking at the wells. Orchards No. 1 and No. 2 were deserted in or after 1891, their trees for the most part being dead, or so nearly dead as to be unattractive to the sapsuckers. A few rods from No. 2 a new orchard was observed by me in 1892. It may be a direct continuation of No. 2, but as all the woodpeckers at No. 2 were supposed to have been shot in 1890,

the chances are that it is a new settlement. In July, 1893, twenty gray birches within an area a hundred feet square had been scarred by the woodpeckers. About half of these were dead, and out of the entire number only four trees were newly drilled and sap-yielding. In many ways this orchard proved to be the most interesting I have watched. The family of sapsuckers using it was not pugnacious, and in consequence other birds visited it much more freely than is generally the case. Downy woodpeckers occasionally sipped at its fountains; black-and-white creeping warblers regularly, though warily, visited its insect hoards, and during the autumn migration of 1892 a pair of yellow-breasted flycatchers spent many days in constant attendance upon its trees, around which countless insects fluttered or hummed.

The four sap-yielding trees at this orchard appeared in July, 1893, to have been appropriated, subject to the prior claims of the woodpeckers, by three humming birds, a female and two males. No one of these birds permitted either of the others or any one of numerous filibustering humming birds to drink at its pre-empted wells. If trespass was attempted, the most furious assault was made upon the intruder, and the possessor was always victorious. Thus, if the female at the eastern tree attempted to approach the western tree, the male on guard there drove her away; while if he entered upon her dominions, he was swiftly repulsed. The details of these meetings were sometimes very extraordinary. In one instance a visiting female persisted for nearly ten minutes in trying to secure a foothold at the western tree. The savage little male met her with his usual impetuous charge, but she dodged him, and began a strange sinuous flight among the branches, back and forth, up and down, round and through, over and under, until the air seemed filled with pursued and pursuer, dizzily maintaining their mysterious flight within from five to a hundred feet of the disputed drinking place. Much of the time the female seemed to be facing the male and flying backward slowly with head erect; then there would come a swift *buzz-z-z*, and a clear space between the trees would be traversed by both birds with the speed of light, a slower flight being resumed the moment foliage was entered. If the male paused in his pursuit, the female drew near again to the coveted drills, and so forced him to renew the chase. Sometimes they moved so slowly that they seemed like bubbles or airy seed vessels wafted by the breeze, and sometimes they flew in short, ever-changing lines, so that the eye wearied of watching them. At last the female gave up the struggle and vanished above the neighboring tree tops.

Frequently the visitors did not come singly, but arrived two or three together, and made combined attacks upon the drills. Then the air would be filled with violent humming and the most

petulant squeaking, as the possessors hurled themselves first at one intruder and then at another, driving them back and forth, as though playing battledore and shuttlecock with them. Twice I saw the male who defended the western tree lock bills with a visiting female and fall almost to the ground in combat; and in several instances I noticed a hotly pursued visitor escape by suddenly doubling, seizing a twig, and then hanging head downward by one foot behind a cluster of leaves. As a rule, the rubythroat, when drinking, makes a perfectly audible humming, the male making a sound somewhat louder and deeper than that produced by the female. It is, however, entirely within the range of their accomplishments to hover silently, and it is not unusual for a visitor to drink silently when successful in reaching a tree unseen. While I never have seen a male rubythroat drink from the drills while perching, I have noticed the female doing so scores of times. In fact, the female at the eastern tree perched nearly a third of the time, sometimes on a twig from which she could lean over and sip the sap, sometimes on the bark itself in a position almost identical with that taken by the woodpecker.

One morning while I was watching the new orchard, a shower came up from behind the western spurs of Chocorua. Thunder grumbled, the sky grew dark, and the wind swished viciously through the slender birches. I wondered what the birds and insects would do when the rain came. From where I sat, I could see dozens of living things, most of which were more or less dependent upon the sapsuckers' orchard. There were four of the woodpeckers themselves, three humming birds, a hermit thrush, two juncos, three chickadees, a least flycatcher; five or six butterflies representing three species; hornets and numbers of flies, ants, and other small insects. As the rain began, the insects, with the exception of the hornets, vanished at once. All the birds, save one of the woodpeckers and the rubythroats, flew out of sight. The remaining sapsucker was a young bird, who looked stupid, and who received the rain by ducking his head and vibrating his tail and wings as a bird does when he bathes in a pool. But the rubythroats amazed me by their conduct. They sought leafless twigs with only the weeping sky above them, and there, apparently with joy, extended their wings to the fullest extent, spread their tails until every feather showed its point, and then received the pelting, pounding rain as though it were holy water. They became so wet that I doubted whether they could fly. *Buzz-z-z!* the vigilant male darted at an intruding female and drove her out of sight, only to see her return again and again in the thickest of the white drops in vain attempts to overcome his watchfulness. It was evident that no ordinary shower could interfere with the whirring wings of a humming bird.

As the season of 1893 wore on, the number of humming birds at this orchard diminished. Late in July I saw as many as five birds near the trees at one moment, three of them being regular attendants and two interlopers. During the next four weeks I was absent, but on my return I found that only the female using the eastern tree remained, and that she was seldom annoyed by visitors. The trees which had been used by the other two birds had run dry, and the sapsuckers as well as their uninvited guests had abandoned them. Of the identity of the remaining humming bird there could be no question; her ways were too strongly marked to be mistaken, as, for example, her invariable habit of alighting upon one slightly sloping trunk when she drank from its drills. When September drew near I watched closely to ascertain the date of the little lady's departure, but day after day came and went without my missing her. At last, on September 1st, it seemed to me that she had gone. I had waited ten or fifteen minutes by the trees and she had not come, though the sapsuckers were busy at the drills in their accustomed places. Before finally giving her up I thought that I would count a hundred slowly and see if this form of incantation might not draw her to her trees. When I reached "ninety-nine" and no bird came, I concluded that the exact date of her migration had been found, but as I said "one hundred" there was a faint hum in the still air, and the dainty dipper appeared with her usual sprightliness. On the 6th, after several light frosts had laid their chilly touch upon the Chocorua country, I felt confident that the tiny creature must have sought a kinder climate. Again, however, she surprised me by appearing, after a long delay, as bright as ever. She hummed at her regular drinking places, but seemed to find little moisture in the wasting fountains. The trees were losing vitality and becoming dry. Then she sought the dead twigs at the tops of last year's trees and flitted back and forth among them, sunning herself. No perch pleased her long, and when she wearied of them all she darted back to the drills for a brief perfunctory sip of the slow-moving sap. Her restlessness seemed born of the season, and a symptom of that fever of migration which was making all bird life throb more and more quickly.

Although on September 25th, when I made my last visit of the year to the orchard, I found two sapsuckers still at work at the drills, no humming bird was with them. How long after the 6th the vigorous little female remained I do not know, for I was unable to watch the trees during the middle of the month.

Although at Chocorua I never have found a sapsuckers' orchard without its attendant humming birds, I am by no means sure that in other localities where both birds occur the same interesting community of interests is to be detected. During a brief

visit to Cape Breton in midsummer, 1893, I kept close watch for sapsuckers and humming birds. Of the latter not one came under my eyes, although common testimony was that they frequented the country. Of the sapsuckers I found one flourishing colony among the alders which bordered the southwest Margaree at the point where that swift stream emerges from Lake Ainslie. More than a dozen alder trunks had been girdled with drills and a rich orchard seemed to be in use. I had not long to wait at the spot, but in the fifteen minutes which I could spare no humming birds came to reward my silent watching.

In some parts of the country sapsuckers are roughly treated on account of their destruction of trees. It is unquestionably true that each family of birds kills one or more vigorous trees each year, but generally the trees are small and of trifling value as timber. My sapsuckers are welcome to several forest trees a year, so long as they continue to attract and feed humming birds, and indirectly to draw thousands of insects within easy reach of their own bills and the more active mandibles of flycatchers, warblers, and vireos.

BARBERRIES: A STUDY OF USES AND ORIGINS.

By FREDERICK LE ROY SARGENT.

THE common barberry (*Berberis vulgaris*), being so abundant over the greater part of Europe, native to the soil, and at the same time both useful and beautiful, has naturally come to hold an important place in popular esteem. As a consequence it has received, in the course of centuries, a considerable variety of names in the different European languages, and some of these names, as might be expected, have undergone rather curious transformations.

Our own name *barberry* is in England more commonly written *berberry*. The variants *barbary*, *barbery*, and *berbery* were used side by side in early modern English, as were *barbere* in still earlier English and *berbere* in the French of that time. There can be no doubt that these are descended from the mediæval Latin forms *barberis* and *berberis*, but further back than this the pedigree is uncertain.

In the change of the terminal from *beris* to *berry* we have, doubtless, an example of one of those transformations which are so apt to take place whenever the foreign name of a common object becomes incorporated into the vernacular, and the sound of the name suggests a common word in any way descriptive of the object. Just as the *écrevisse* (crevice-dweller) of the French became the "crayfish" of the English, from its aquatic habits,

and the *asparagus* of the botanist is the "sparrergrass" or "sparrowgrass" of the marketman, so we may conclude that the character of the barberry's fruit decided the change of name referred to.

The first syllable of the English name is, doubtless, as unmeaning as the corresponding part of "crayfish," or its rival form "crawfish." Perhaps in both these cases the lack of any signifi-

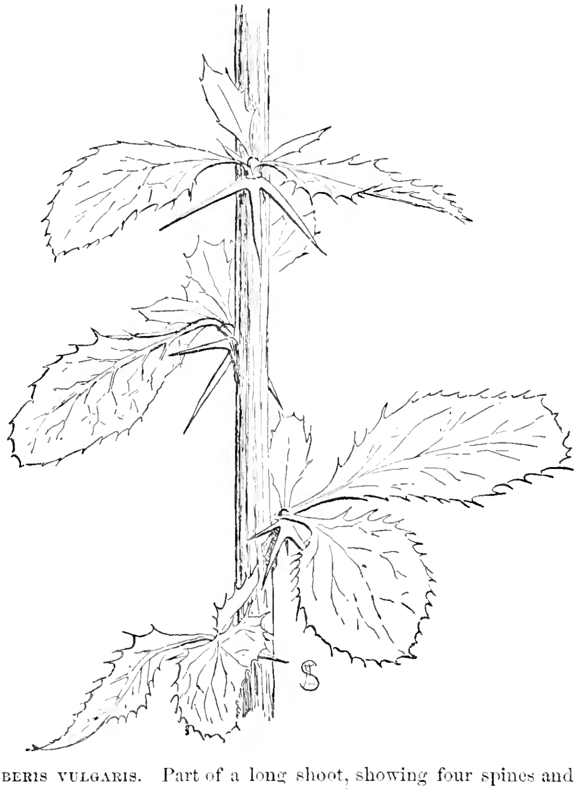

Fig. 1.—Berberis vulgaris. Part of a long shoot, showing four spines and as many short branches bearing leaf rosettes.

cance in the first part of the words may have favored the continuance of two forms side by side.

Various conjectures have been offered as to the origin of the mediæval Latin *barberis* and *berberis.* Most commonly the Latin name is said to be derived from the Arabic *barbārīs* or *berbêrys* ;* but, according to Murray and the Century Dictionary, the Arabic form and the Persian *barbari* are both derivatives of the Latin. Wittstein † suggests a derivation from the Greek *berberi,* a mussel, from the mussel-like form of the leaves. The conjecture which assumes the plant to have been imported into Europe

* Gray's Manual, sixth edition. † Etym. bot. Handwörterbuch, 1856.

from Barbary, in Africa, does not harmonize well with what is known of the plant's distribution.

To return, then, to the Latin form, however it may have originated, we find it giving rise to the English *berberry* in a manner suggestive of adaptation to a new linguistic environment. By a somewhat similar process have probably arisen from the same original the form *pepperidge, pipperage, piperidge,* and *piprage,* by which the plant is popularly known in parts of England and Ireland. The ease with which the closely similar sounds *b* and *p* can pass one into the other, taken in connection with the obvious resemblance of the barbery fruit to small red peppers, doubtless gave direction here to the obscure forces which bring about the corruption of words.

The same Latin root makes its appearance in several names used in Germany. Thus, among those given by Adelung (1774) are *Berbeisze, Berbis, Berwitze.* The name most commonly met with in modern books is *Berberitze,* which, in view of the circumstance that *ritzen* means to scratch (apropos of the spines), surely looks like another case of assimilation, analogous to what we found in English. That the Germans are fond of embodying in their names of this plant some reference to its more or less obvious qualities or uses is sufficiently proved by the following list gathered from various lexicons: *Sauerdorn* (sour thorn), *Essigdorn* (vinegar thorn), *Weinschierling* (wine hemlock), *Weinnäglein,* wine clove), *Weinäuglein* (wine eye), *Kreuzdorn* (cross thorn), and so on.

Fig. 2.—Berberis vulgaris. A leaf rosette and flower cluster.

In French, besides the older *berbere,* and the form *berberis,* which is in common use to-day, we have *épine-vinette,* which Littré considers may have been given to the plant either because of its clusters of berries, resembling grapes, or because a sort of tart berry wine is made from them, or else because of its acidity, *vinette* being in many provinces the name of sorrels, sour grapes, and the like. This last supposition would make the name a counterpart of the German *Sauerdorn.*

The Spanish *berberis* and the Italian *berberi* do not, of course, call for any special explanation. Without attempting to make a complete list of the names which have been applied to this plant,

enough have been given to show that, at least in the history of those forms cognate with our own *barberry*, there are presented not a few curious and perhaps significant analogies with the evolution of a group of organic species subjected to the diverse influences of changing environment.

Leaving now the matter of names, let us proceed to consider the plant itself, and, so far as may be, something of its history.

The barberry's place in Nature is expressed botanically by saying that it belongs to the principal genus of the family *Berberidaceæ*, and is thus near of kin to our native "twinleaf" (*Jeffersonia*), "cohosh" (*Caulophyllum*), and "May apple" (*Podophyllum*). As will be seen by referring to Fig. 3, the floral structure is, like theirs, notably simple and regular, and the parts are all distinct, thus recalling the general features to be found in the buttercup family (*Ranunculaceæ*) and the moonseed family (*Menispermaceæ*). It evidently is of the same ancestral stock as these, since they all agree so closely in fundamental plan, despite innumerable differences in matters of comparatively small detail. Moreover, the intense yellow color so generally characteristic of the tissues of *Berberidaceæ*, depending, as is well known, upon the presence of the bitter alkaloid *berberine* ($C_{20}H_{17}NO_4$), occurs also to some extent in the families mentioned. Hence the structural evidences of consanguinity gain something of confirmation in the fact that we find the same substance which renders various species of *Berberis* useful for medicinal and tinctorial purposes imparting its tonic properties and intense yellow to the "goldthread" (*Coptis*) and "yellowroot" (*Xanthorrhiza*) among *Ranunculaceæ*, and the "calumba root" (*Jateorrhiza*) of *Menispermaceæ*.

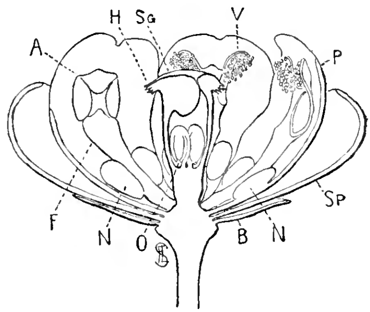

FIG. 3.—BERBERIS VULGARIS. Vertical section of flower: B, bract; SP, sepal; P, petal; N, N, nectar glands; F, filament; A, anther; V, valve; SG, stigma; H, zone of hairs; O, ovule.

In the old days of belief in "signatures," this yellowness of the barberry's tissues was taken as a sure indication that here must be a sovereign remedy for jaundice, and accordingly a decoction of the bark was in high repute as a specific for that disease. While this notion has, of course, long been banished to the limbo of imaginary medicine, yet, in the modern practice, decoctions, infusions, and the fluid extract of barberry bark, as well as the isolated alkaloid berberine, have a recognized tonic value. It is an aqueous extract prepared in India from the sliced roots and branches of the so-called "ophthalmic barberry" (*Berberis ly-*

cium), and other Himalayan species, which constitutes the highly valued "rusot."

Considered from the plant's standpoint, this bitter principle, so abundantly present in its outer tissues, is doubtless to be regarded as a defense against gnawing animals, and as such, accessory to the spines which can be effective as a protection only against the larger animals which feed upon leaves. Thus, as often happens with the plants of our pharmacopœia, the very means adopted for its preservation becomes the object of its being destroyed for man's use.

But the barberry has more to contend against than the attacks of animals. As a native of regions visited by heavy storms of snow and wind, its branch system (often eight to ten feet in height), even though it be rid of its leaves through the winter, must, nevertheless, be subjected to a very considerable

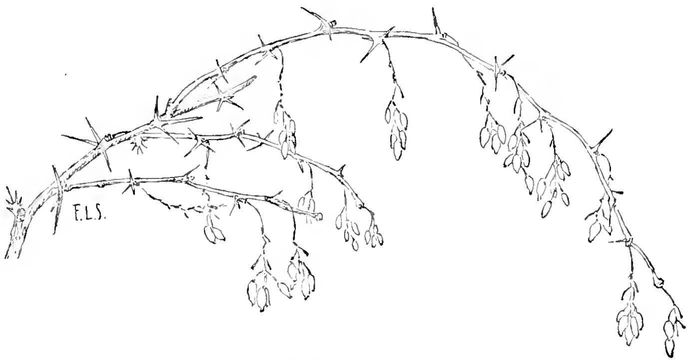

Fig. 4.—Berberis vulgaris. Leafless branches, showing clusters of fruit and different forms of spines.

mechanical strain. A glance at the vegetative organs of our plant will show with what efficiency and economy of material this bit of engineering is accomplished.

First of all it will be noticed that there are two remarkably different sorts of branches (compare Figs. 1 and 4). The one sort, long, slender, and arching, are armed with the stout spines already referred to; while the others, originating from the axils of these spines, remain very short, although bearing year after year, through the summer, each a rosette of leaves. All who have observed the effect upon our trees and shrubs of one of those storms which load everything with snow and ice must have seen that the plants which received least damage were those in which there was either unusual stoutness of material or else such an attitude and flexibility in the branches as enabled them to bend readily under a load or other strain. Now, in the branch system of the barberry bush we find all these character-

istics most happily combined; for, thanks to the plant's economy in making the rosette branches so short, an abundance of material is available for the construction of those elongated ones which are to perform the special work of mechanical support.

In the course of its first year one of these elaborately organized shoots may attain a length of two feet or even more. During this rapid growth only a little wood is formed, but in the young bark there are developed about a dozen strands of tough, elastic fiber, which show as prominent ridges at the surface. These strands continue for a year or so to impart such strength and elasticity to the branch that when bent downward, even to a radius of two or three inches, it will spring back to its original curve. After the second or third year the bark and its fibers become brittle and weak through wear, but in the meantime the wood within, at first so meager, has been increasing, ring upon ring, around the central pith, so that, before the bark has ceased to be of mechanical service, there has already been formed to take its place a tissue possessing fully as much elasticity as the other, and in addition remarkable toughness and durability. These qualities are even more apparent as the wood grows older; so much so, indeed, that it is highly valued in turnery and the manufacture of archers' bows. Thus we see that when a storm comes, the barberry can meet the emergency with branches which yield gracefully so long as they are young, but with age become most effectively resistant.

Still, a moment's consideration of the distribution of strain will show that for all this flexibility and stoutness throughout the length of the branches a serious dismemberment of the plant must ensue if the place of juncture between each long branch and its trunk be not strongly re-enforced. Now, the long branches of the barberry arise each as a continuation of the axis of a rosette branch. While these short branches have only a cluster of leaves to support, they are but weak, brittle affairs, composed chiefly of soft pith with only a sparse supply of woody fibers; but when the short axis comes to serve as the basal part of a long shoot, not only does the wood increase remarkably, but even the pith becomes hard and firm. Moreover, we find throughout the whole plant that, whenever a branch is called upon to sustain a considerable load, its base is proportionately thickened and strengthened, and the same is true to a marked degree of the main trunk at its juncture with the root.

Although with us barberry bushes are for the most part denizens of the open, in Europe they are reported as often growing at the margin of woods. When in this situation, the branches become much more elongated, and, by using the recurved spines as grappling hooks, they climb over the shrubbery encompassing

the tree trunks, and finally gain support upon the branches of the trees themselves. Unlike ordinary vines, however, which only injure the plants that support them, the barberry may be of some service, as its armament of spines is well calculated to repel intruders.

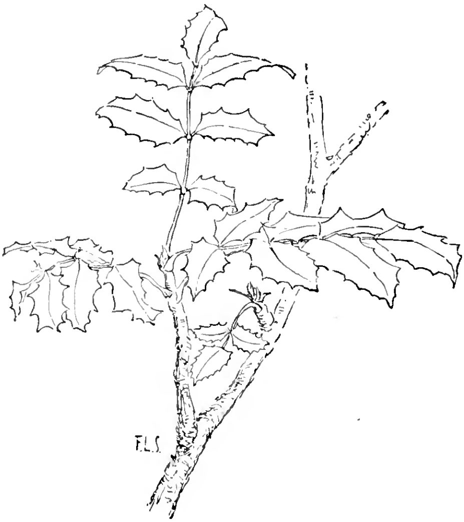

Fig. 5.—Berberis aquifolium. Leaves and branches.

The great aim of all this spread and strengthening of branch work is of course to secure the most advantageous exposure of foliage to light; to the attainment of this object the form and arrangement of the leaves themselves also contribute not a little. Wherever we find such rosettes of wedge-shaped leaves as the barberry produces, the likelihood of one leaf overshadowing its neighbor is much reduced, and when as in shady localities this matter is of special importance, it is a noteworthy fact that the leaves commonly adapt themselves to each other so perfectly that a cluster becomes almost equivalent to a single large shield-shaped blade. Moreover, on the more horizontal shoots the margins of contiguous rosettes dovetail into each other so neatly that the result may be justly compared to a mosaic of leaves.

Another peculiarity connected with that abbreviation of the branchlets which results in the rosette arrangement is the method of defoliation. When the time arrives, the leaves, instead of separating entirely, drop only the blade, while the flattened overlapping leafstalks remain attached to the stem and perform the function of bark for several years.

It will thus be seen that we have in the barberry one of those rare cases (paralleled by certain species of orange, grapevine, and creeper) in which an apparently simple leaf has the blade articulated with the stalk after the manner so characteristic of the leaflets of compound leaves (Fig. 8). Of the hundred or more known species of *Berberis*, about twenty (forming the subgenus *Mahonia*) have compound leaves of from three to many leaflets all plainly articulated at the base (Figs. 6 and 7), just as is also the case with certain species of the genera *Citrus* and *Vitis*, to which the orange and the grape respectively belong. Moreover, throughout the *Berberidaceæ* we find almost all the species to pos-

sess leaves which are obviously compound, the chief exception being those eighty species (forming the subgenus *Euberberis*) which in their leaves agree essentially with *Berberis vulgaris.* In view of these facts, botanists have been led to adopt the somewhat paradoxical theory that leaves of the euberberis type are in reality compound though unifoliolate.

The question as to how such a curious state of things could have come about is so closely connected with what concerns the evolution of the other vegetative organs that we shall do well to consider them all together.

In attempting to reconstruct for ourselves the main features of the original ancestral barberry we are much helped by the fact that besides *Berberis vulgaris,* which is the only representative of the genus in central Europe, there have been developed a multitude of species in Asia and a still larger number in the two Americas; for it is clear that this must considerably increase the chances of our being able to find something like the primitive form persisting in certain living species. Guided by the principle that evolution is for the most part attended by increase of differ-

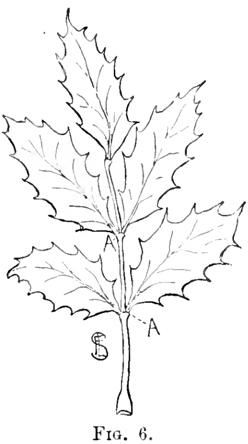

Fig. 6.

Fig. 7.

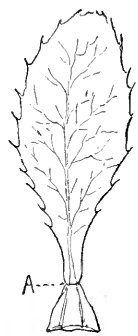

Fig. 8.

Fig. 6.—Berberis aquifolium. Quinquifoliolate leaf.
Fig. 7.—Berberis trifoliata. Trifoliolate leaf.
Fig. 8.—Berberis vulgaris. Unifoliolate leaf. A indicates the point of articulation of the leaflet.

entiation, we may fairly assume that the branch system of the prototype differed from *Berberis vulgaris* in having the internodes approximately equal, thus making the lateral branches on the one hand and the main branches on the other more nearly of a length and all the leaves uniformly disposed in elongated spirals.

Such a condition is indeed tolerably well exhibited in the mahonias, as may be seen in the "holly-leaved barberry" (Fig. 5),

which is a fair example of the *Mahonia* group. At the same time it is worthy of note that along with the greater uniformity of the branches is associated the possession of compound leaves having from three to many leaflets. This fact, taken in connection with the circumstance that almost all the other members of the family have the leaves more or less plainly of the palmate type, makes it probable that the ancestor of the barberries had trifoliolate leaves not unlike those often found interspersed among the larger leaves of the multifoliate mahonias and appearing also as the sole form on other species of the same subgenus (compare Figs. 5 and 7). It is significant, moreover, that the mahonias are without the highly developed spines so characteristic of the *Euberberides*, but depend for protection upon the spiny margins of their evergreen leaflets.

Thus, whether we consider the approach toward similarity among the branches, the approximation in the type of leaf to that most common in the family, or the absence of specialized spines, we are led to the conclusion that the *Mahoniæ* since they exhibit so much less differentiation than the *Euberberides*, must therefore represent more nearly the primitive features of the genus—a conclusion which is confirmed by such paleontological evidence as we possess. For the five species discovered in the Tertiary formation of southern France, northern Italy, and Switzerland are all mahonias, one of them (*Berberis helvetica*) closely resembling the American holly-leaved mahonia here figured, while others are like forms living at present in China. In view of these facts we shall probably be not far from the truth if we picture to ourselves the ancestral *Berberis* as being a small bush or underbrush resembling in a general way our evergreen holly, but having in place of each simple leaf a compound one of three leaflets. Almost exactly corresponding to this description is the already mentioned *Berberis* (*Mahonia*) *trifoliata* of Mexico and the adjacent regions.

That the ancestral home of the barberries was most probably in the northern part of North America appears from what is known of the geographical distribution of the species when viewed in the light of the generalizations arrived at by Bentham, Hooker, and Asa Gray regarding the origination of the members of the north temperate flora. We learn from Bentham that "to the great majority of them no primeval antiquity can be ascribed in central or western Europe; they appear to have come from the East, a considerable number perhaps from western Asia, where their types appear to be more varied, but many also must have made half the tour of the globe. Large American genera have sent out offsets into eastern Asia, which, gradually diminishing in number of species and sometimes slightly modifying their character, have

spread over the whole of Asia, and invaded almost every part of Europe."* Of these latter genera *Berberis* is surely one.

Geologists tell us that the climate even of arctic America during the Mesozoic era was as warm and equable as that of our Southern States to-day. The same was true of northern Europe and Asia, and there is good reason to believe that between the latter and America there was during Mesozoic times a continuous land connection in high latitudes, or at least a chain of islands uniting the two continents. Such were the conditions then under which we may suppose a berberidaceous herb to have acquired the shrubbiness and other characteristics which distinguish barberries from the rest of the family.

As the descendants of this trifoliolated, woody form multiplied and spread over the vast territory open to them, the modifications which arose must have progressed along two principal lines of development. The first to diverge was doubtless the line of pinnate-leaved mahonias. To explain the development of such a leaf from the trifoliolate ancestral form, we have only to suppose the terminal leaflet to become stalked and then divided into three, just as we must conceive the trifoliolate leaf to have been derived in the first place from a sessile, simple-bladed one. From such trichotomy of the terminal leaflet would result a five-foliolated leaf (Fig. 6); but let the process be repeated with successive terminal leaflets a sufficient number of times, and the most highly developed mahonia leaf is readily accounted for. This view accounts, moreover, for the curious circumstance that in these leaves there is, in addition to the articulation between leaflet and rhachis, a transverse articulation extending across the rhachis between each pair of leaflets (Fig. 6 A). For what can this be but the representative of that terminal articulation which was once at the base of a leaflet since differentiated into all those parts of the leaf now lying above the articulation ?

Along with the multiplication of leaflets there appears to have been a lessening of the number of leaves and some shortening of the branches, which affected the lateral ones somewhat more than the primary axes; but beyond this the changes introduced concerned only matters of small detail. The descendants of this new form spread into Asia and thence into Europe, where we find some remains of them in the deposits of the Tertiary. Subsequently, in the course of that general lowering of temperature which culminated in the Glacial period, these pinnate-leaved species were exterminated in Europe, while in Asia and America, where a more southerly extension into warmer regions was possible, they were able to survive and spread northward again after the retreat of

* Nat. Hist. Review, p. 370.

the glacier and so take up their home in the localities we find them to-day. That such a form as *Berberis trifoliata*, which retains so fully the primitive characteristics, should remain in Mexico, seems to find a sufficient explanation in the fact that the climate of this region resembles most closely that of its supposed northern home in preglacial times; or, in other words, we may look upon the persistence of the original form as connected with the continuation of similar climatic conditions during the life of the species from the time when the genus first appeared.

While the ancestors of our modern mahonias were seeking an asylum in lower latitudes, certain other descendants of the primitive trifoliolate barberry were in all probability enabled to hold their own much longer against the encroaching cold, by developing those adaptations to extremes of temperature which make the various forms of euberberis so well suited to their present home.

We have already seen the advantages which come with differentiation of the branch system when plants are to be subjected to the storms of a severe winter. Such differentiation, however, means not only a more efficient disposition of the mechanical elements in the stem part of the plant, but it involves a closer and closer crowding of the leaves on the shorter branches until the limit of crowding is reached in the rosette. Obviously trifoliolate leaves are ill suited for such an arrangement—the lateral leaflets would be so much in the way. The causes which bring about the reduction and final disappearance of parts that have become useless or harmful to a species could not fail, therefore, to affect these leaflets until the present unifoliolate condition was reached. Moreover, in the absence of lateral leaflets there would be less need for an elongated leafstalk, and we should expect, therefore, just such an abbreviation of this organ as we actually find in a large share of the species of euberberis. We have already noticed how this enables *Berberis vulgaris* to turn its petioles to good account, by keeping them as protective bark scales long after the leaf blades have fallen.

It is in harmony with our conclusion that the ancestral barberry was a holly-like plant, whose descendants became modified under the influence of gradual refrigeration, to suppose that the earlier forms of euberberis were evergreen. So far as their migrations enabled them to continue living under conditions of climate favorable to the retention of leaves throughout the year, this habit might be expected to be present. This we find is the case with species in central Asia and in the mountainous and temperate parts of South America. Even in a region of much snow and ice no serious disadvantages need be feared, provided the plant does not extend its branches far above the ground. This will doubtless explain the presence of the evergreen mahonia

undershrubs in our Western States, as well as other apparent exceptions among *Berberides* to the general principle we are now applying.

Along with the firm texture belonging to evergreen leaves there would naturally be retained the marginal spines which protected the mahonia ancestors from browsing animals. But with the establishment of the rosette arrangement the leaves which are borne by a long shoot, in virtue of their position just below the rosettes, come to have a special importance in this protective capacity. For, in the first place, as being already fully developed at a time when the rosette leaves are young and tender, the old leaves can shield the newer ones at the most critical period of their life; and, in the second place, given one stout, spiny leaf in such intimate connection with the mature cluster, and the need for using up material in spine-making for the latter is much lessened. Accordingly, we find very generally throughout the evergreen *Euberberides*, along with the differentiation of the branches into long and short, a differentiation of the leaves—those subtending the clusters being decidedly spiny, while those of the cluster are less strongly armed. A particularly good example of such differentiation not far advanced is afforded by a species growing in Chili (Fig. 9). In a number of cases, such as the "box-leaved barberry" (*Berberis buxifolia*, Fig. 10), the differentiation has been carried so far that the subtending leaf has been completely transformed into a formidable spine, while the rosette leaves have lost all trace of spines except at the tip.

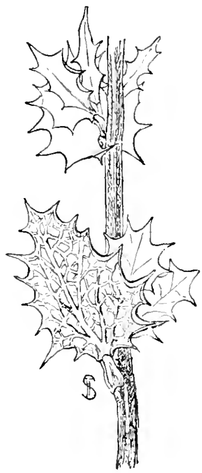

FIG. 9.—BERBERIS TOMENTOSA (?). Leat rosettes subtended by stouter spiny leaves.

After the plurifoliolate and the unifoliolate types of evergreen barberries had been evolved there was the further possibility of developing from the latter a yet higher type which should be still better adapted to meet the exigencies of a severe and snowy winter, and at the same time safely attain a considerable height. All this would follow from the acquirement of the deciduous habit.

In the series of forms which came to adopt the expedient of defoliation at the approach of winter, several causes may have conspired to bring about in the two sorts of leaves a still further specialization of the two functions of assimilation and defense, which, originally combined in each leaf, began, as we have seen, to be separated more or less in the evergreen *Euberberides*.

As regards the subtending leaves, not only would their importance as a defense to the young rosette be sufficient to insure their

persistence through the winter, but the same reason which made the defoliation of the rosette advantageous—namely, decrease of the surface on which snow might lodge—would favor a reduction of lateral spread in the persisting leaf blades. Moreover, assimilation could not, of course, be carried on during the winter, and so the green parts of the leaf could well be spared to afford the material necessary for making the spines firmer and longer. Thus would finally result a purely defensive organ, so much the more efficient because having no other function to perform. Our common barberry exhibits especially well (Figs. 11 and 4) not only the more highly developed spines, but the intermediate stages connecting these with the primitive spiny leaf. Toward the tip of the uppermost shoots we find slender, one-pronged spines; the next below these are three-pronged, while those toward the base of the same shoot may have the prongs five or more in number. Passing now to one of those shoots, known as "suckers," which spring from older (mostly subterranean) parts of the plant, we find in addition to the forms of spines already noticed, others (Fig. 11, A–D) in which foliar characteristics become more and more evident as we approach the base of the shoot, where occur spiny leaves (A) essentially like what we have assumed to be the ancestral form. In regard to the position which these different forms occupy in relation to the ground or to their proximate basis of support, it is worthy of note how nicely all this accords with the theory of their having been developed under the influence of snowy winters.

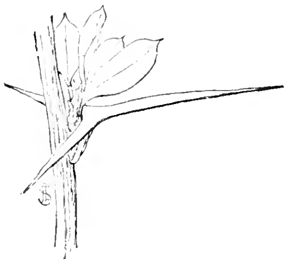

Fig. 10.—Berberis buxifolia. Leaf rosette and spine.

To the rosette leaves the limiting of their duration to the warmer part of the year would permit a much thinner texture than was formerly necessary, and in consequence a more extended spread. This would of course involve a corresponding weakening of the marginal spines, but these being now so fully superseded in function, might safely be reduced to such slender cilia as we now find on the leaves of our common barberry (Fig. 8), or indeed be done away with altogether, as not infrequently happens in the same plant. They are clearly rudimentary organs tending to disappear.

A further consequence of the increasing severity of climate was the need of some special means to protect the tender organs of the bud against harmful changes of temperature. So long as these changes were comparatively slight and one set of leaves remained in place while the others were developing, the sheathing bases of the former served as a loose protective covering which answered every purpose. This supplementary function obviously

fell to the lot of the last-formed or uppermost leaves of the set. As need arose for better protection of the infant shoots, the simplest way of meeting it would be to increase the efficiency of the parts already in use by widening them as far as might be necessary. As this was going on, the same fate which overtook the lateral leaflets of the original three would now extend to the terminal one of each of these upper leaves; for with the shortening of the stem they would be brought to lie so closely above the others as to shade them injuriously if not reduced in size. Moreover, as being the latest to develop, they would get but a small share of the reserve food provided for the rosette. Still, their relation to the supply of nutriment as well as their uselessness or power for harm in the rosette would, after all, be more a matter of degree than in the case of the lateral leaflets, since these latter would have to lie practically in one plane and so must interfere not only with the terminal leaflets but with each other. This may help us to explain why, although the lateral leaflets have so en-

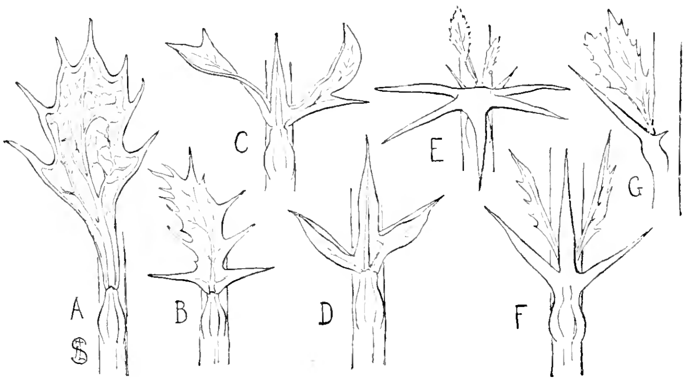

FIG. 11.—BERBERIS VULGARIS. Series of spiny leaves passing into spines.

tirely disappeared, we still find on some of the lower bud scales traces of a blade which thus afford connecting links in our morphological chain (Fig. 12).

This evolution of the bud scales must, of course, have been closely connected with that shortening of the petiole which we have already noticed in the typical rosette leaves as having culminated in the production of persistent overlapping scales forming an outer bark for the secondary branches; and it would seem most probable that the development of bud scales and bark scales proceeded side by side. Finally, as accounting further for their similarity of form, it may be remarked that in both, the protective function, at first merely incidental to that of mechanical support, comes at length to be the sole use for which they are retained: in one case it is a matter of years, in the other of generations.

For the propagation of barberries gardeners often take advantage of those adventitious shoots or "suckers" before mentioned which spring from near or beneath the surface of the ground. These, separated from the parent and planted in suitable soil, strike root after the manner of a willow twig and develop into a shrub. With wild barberries, if the main part of the shrub happens to be fatally injured, suckers proceeding from parts of the root even remote from the stem may continue to live and thus perpetuate the stock in the same locality.

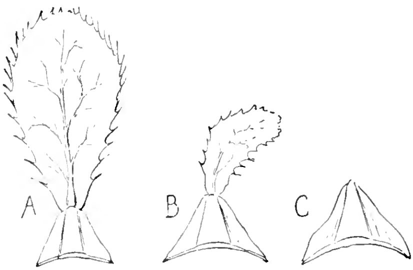

Fig. 12.—Berberis vulgaris. Transition forms connecting foliage leaf with bud scale.

In Nature, however, it is upon seedlings that the chief dependence is placed for the continuance and spread of the species. Having now considered, as fully as present limits will permit, the phenomena connected with the barberries' vegetative life, we will next turn our attention to the special peculiarities of flower and fruit which contribute more or less directly to the production and care of offspring.

[*To be concluded.*]

COMMERCIAL POWER DEVELOPMENT AT NIAGARA.

By ERNEST A. LE SUEUR.

As many of the readers of The Popular Science Monthly are aware, there is a great engineering project on foot at Niagara Falls, looking to the development of a part of the water power at present running to waste over the gigantic cataract. A company, or rather an association of companies, working for a common end, is at present occupied at the falls with the object in view of utilizing the power commercially.

That this situation is the finest in the world for developing mechanical power has long been realized, but the local demands at Niagara were comparatively trifling, and only lately have our facilities for transmitting power over distances become sufficiently developed to warrant such an undertaking as is now in hand. The power company does not, however, look entirely to distant points for consumers of their output; on the contrary, a very large amount will be used almost on the spot by manufactures which are now moving to Niagara. The variety of purposes to which this power will be put may be gathered from the

fact that they are as diverse as the manufacture of "mechanical" wood pulp and the smelting of aluminum.

There are already at the falls a few establishments using power developed by turbines, and which have been quietly at work for years. There is a canal known as the Hydraulic Canal on the American side, skirting the city of Niagara Falls, and terminating on the cliffs, half a mile below the cataract. There are a number of mills here which, for the most part, however, utilize only a fraction of the total fall available, probably for the reason that when they were built there were not in existence the high-grade water wheels suitable for great head that are on the market to-day.

People in general have the idea that the Niagara water power is inexhaustible, and so it probably is, so far as human requirements go. There are, however, some tolerably close data on which to figure the total horse power. The Lake Survey Board and Mr. R. C. Reid, examining the matter independently, have come to a very fair agreement in their conclusions on this point. From their figures it would appear that the average flow is about 270,000 cubic feet per second, and this is almost exactly the same as the almost unthinkable quantity of 1,000,000,000 pounds per minute. A horse power of work is the equivalent of 33,000 foot pounds per minute, and as the weight above mentioned falls 161 feet, the horse power of the total is expressed as follows: $161 \times 1{,}000{,}000{,}000 \div 33{,}000 =$ close on five million.

Owing to the lack in full efficiency of even the best commercial turbine wheels, we may take the limit of power that could be developed as about 4,000,000 horse power.

The average power is not departed from to any great extent at different seasons, as is the case with other water powers, because the spring thaws and summer droughts affect hardly at all the level of Lake Erie, from which the falls get their supply.

The system of Great Lakes above Ontario would require a year in order to have their level reduced by three feet and a half by even the enormous drain of a thousand million pounds of water per minute above referred to, supposing the system to be entirely cut off from its normal supply. A paper by Mr. R. C. Reid before the Royal Scottish Society of Arts in March, 1885, gives the folling data: Total water-shed area down to Niagara, 290,000 square miles; total lake surface, 92,000 square miles; average rainfall in the lake district, thirty-six inches—and that we may assume twenty inches annually of evaporation and absorption, leaving sixteen inches over the whole area finding its way to the lakes. From the lake surface proper, there occurs evaporation to the extent of twenty-four inches per annum. Further, in reference to the enormous storage capacity of the system, he shows

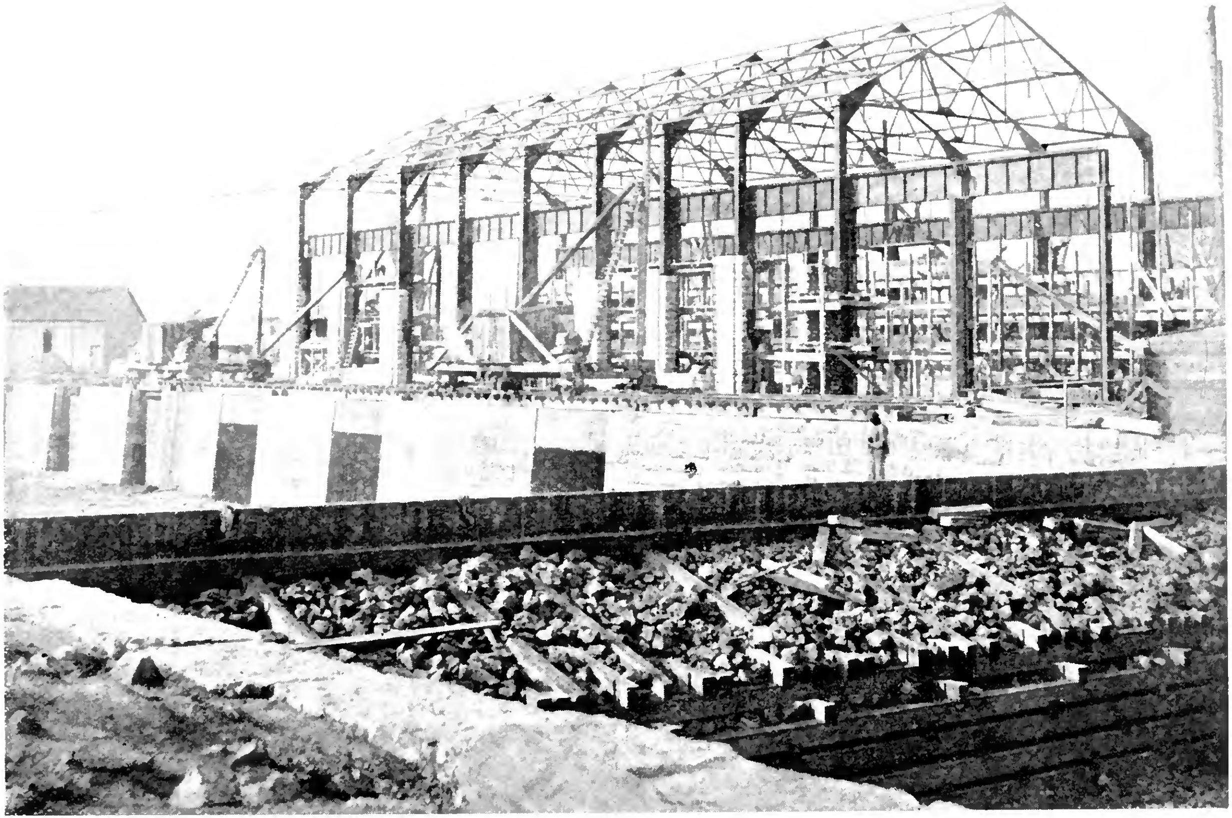

Fig. 1.—Skeleton of the Power House.

that "it would take six months for the full effect of a flood in Lake Superior to be spent at Niagara Falls." It is easy, therefore, to understand how little fluctuation of level there can be due to seasonal variation in rainfall. Thus we see that quite apart from the fact of the vast volume and head available, and of there being no necessity for building a dam to back up the water, the situation is peculiarly favorable to the development of a constant power all the year round.

In spite of the generally equable level of Lake Erie, there are sometimes very considerable fluctuations, not of volume, but of distribution, due to high winds sweeping the length of the lake and causing a considerable banking of water at the end blown into. Sometimes such storms have lasted for days, and have had a very noticeable effect in increasing or diminishing the volume going over the fall. A more serious cause of low water is an ice jam at the head of the Niagara River. It is on record that in March, 1847, the water practically ceased to flow, "not enough going over to turn a grindstone," as a local paper had it at the time. These two circumstances do not, however, affect the evenness of flow to any extent worth mentioning compared with the seasonal variations in rivers in general.

The total fall between Lakes Erie and Ontario is three hundred and twenty-nine feet, and is made up as follows: From Lake Erie to the head of the falls, seventy feet; the falls, one hundred and sixty-one feet, and below to Lake Ontario, ninety-eight feet. Consequently, the total power running to waste is more than double the five million horse power on the falls. An idea of the proportion that this total bears to what may be called the world's consumption of power may be had from the fact that it is computed to be equal to the total of all the steam-generated power in the world.

The geographical situation of the falls with respect to nearness to the at present great power-consuming centers is, as hinted above, not quite all that could be desired; but there are, nevertheless, several cities within reach, electrically speaking, which will use an enormous amount. Buffalo may be said to be next door, and Rochester is within easy reach. In the not too distant future we may expect to see the great electrical manufacturing works in Schenectady operated, as is meet, by electrical power from Niagara.

The power company has, however, made branch track connections between the territory owned by it and three important railway lines which all pass within a few miles of the property. These connections and the good freight rates which have been contracted for in various directions, together with the cheapness of power, will in all likelihood attract to the spot manufactures

besides those which have already undertaken to go there, to an extent that will make it the foremost power-consuming center in the world.

The chief piece of work in connection with the power installation has been the construction of what, in almost any other situation, would be termed the tailrace. In this case the head utilized is so great that what is ordinarily understood by a tailrace would be an artificial chasm of abysmal proportions that would almost require illumination other than the natural to be visible to the bottom at midday. Instead, a tunnel has been excavated, of which

Fig. 2.—Open End of Tail-race Tunnel.

the dimensions are so remarkable as to make it unique among engineering exploits of the kind.

The location of the power house, on account of difficulty in acquiring sufficient adjacent lands and rights of way and for other reasons, is not very close to the falls. The Cataract Construction Company has established itself about a mile and a half above the American Fall, and has dug a canal of considerable width, of a depth of twelve feet, and length fifteen hundred feet. Along its edge for a distance of at present one hundred and forty feet is dug a great trench or slot one hundred and sixty feet

down, with arrangements in the form of gates in the masonry wall separating it from the canal, by which water may be admitted to penstocks placed vertically in the slot and supplying the turbine wheels. A penstock, as many of our readers are aware, is a great tube, usually, in these days, of boiler plate, of a diameter running up, it may be, to thirteen feet, conveying water under head into the wheel case in which the turbine revolves.

In the present instance the penstocks, which are seven and a half feet in diameter, seem very small, considering that they each supply a pair of wheels of five thousand horse power, but that is on account of the enormous pressure under which the wheels work, giving a greater power for a given volume of water than with the smaller heads more commonly used.

The turbines discharge their waste water into the tunnel above referred to, which is no less than six thousand seven hundred feet long, and which discharges into the chasm below the falls just past the Suspension Bridge.

The details of this tunnel, which was excavated through three shafts, one in the face of the cliff and two vertical ones, are as follows: Length, six thousand seven hundred feet, and sectional area three hundred and eighty-six square feet throughout, the average height and width being about twenty-one and nineteen feet respectively. The cross-section somewhat resembles a horseshoe. The excavation was much larger than the finished inside dimensions, on account of the subsequent lining with four courses of brick. The mouth of the tunnel has, besides, a lining on the top and sides of iron. The work has been done most substantially and is built to stay. The tunneling was done through strata of limestone and shale, and harder material was met with than had been expected in the beginning, so that the three million cubic feet of excavation has cut a very important figure in the total cost of the power plant. The tunnel has a grade of 0·7 per cent (seven feet fall per thousand length), and runs directly under the city of Niagara Falls to the lower river level.

The work of excavation was carried on on three benches, dividing the total height of twenty-six feet about into three equal portions.

The whole undertaking has been so entirely novel in many ways that the engineers in charge have had their resources taxed to the utmost in overcoming the various difficulties that presented themselves during the design and construction of the power house, electrical and hydraulic apparatus, and tunnel. The power-house building is as yet of comparatively small proportions, but is intended to be enlarged as the number of dynamos and turbines is increased. It might be thought, and was thought at first by some of the projectors of the scheme, that the great amount of power

that was to be developed would admit of considerable subdivision, not only of the units of power production (each unit consisting of a turbine and generator), but also of the ways in which the electrical power would best be sent out to consumers.

As already mentioned, a number of manufacturing establishments are locating themselves on the property owned by the Cataract Construction Company, and to these it would at first sight seem natural and best to deliver electrical power straight from the power-house generators to their motors, seeing that this could easily be done without much loss of voltage on the carrying line: and, on the other hand, for distant work, as at Buffalo and Roch-

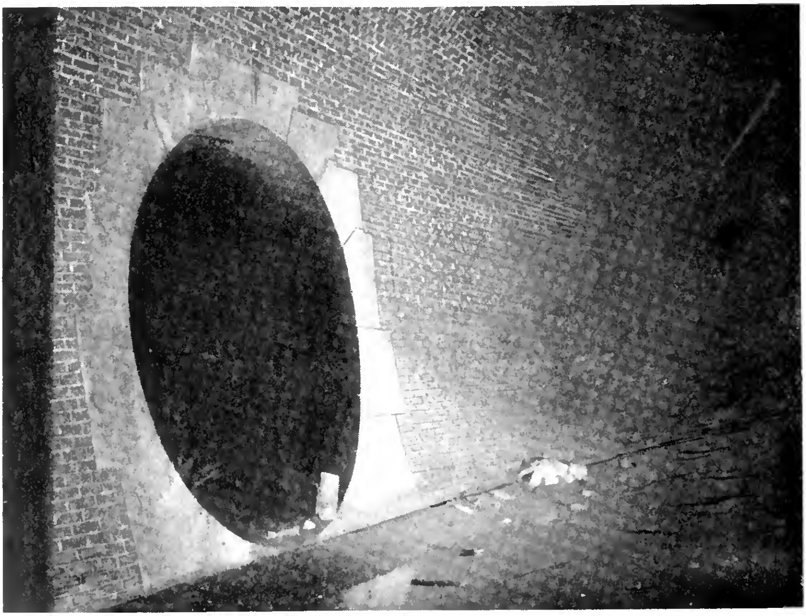

Fig. 3.—Interior of Large Main Tunnel, showing Junction of Lateral Tunnel from Niagara Paper Company's Wheel Pit.

ester, to use a high potential on the line with transformers at the consuming end or at both ends. It has, however, been decided not to thus take advantage of the mechanical subdivision of the plant to use different types of generators for different kinds of work, but to adopt as a standard one good form of machine and use it throughout, at least until the plant is increased.

Perhaps the most remarkable consequence of this step will be that the Pittsburg Reduction Company, which manufactures metallic aluminum by the action of electricity upon certain compounds of that metal in a state of fusion, and which expects to use some thousands of electrical horse power when established at the falls, will receive it in the form of an alternating current,

which will be passed into an alternating-current motor driving a direct-current, low-voltage generator furnishing at last the desired electrolyzing current. It has seemed best to submit to this complication of apparatus in order to gain the advantage of entire uniformity and interchangeability of power units in the generating plant. Of course, if the power company were to put in a direct-current dynamo for the benefit of the Reduction Company, all that would be necessary would be to send the current over a wire straight to its work; and it seems remarkable, in view of the thousands of horse power required, that the extra expense of a motor and dynamo to transform this quantity appears preferable.

The electrical power unit which has been decided on after the most exhaustive, and presumably competent, expert examination of the requirements of the situation, will be of a capacity for continuous work of five thousand electrical horse power (or three thousand seven hundred kilowatts), and will be directly connected with a pair of turbines of similar power. All the generators will be mechanically identical in construction and have parts interchangeable with each other. The advantage of this, besides the obvious one of having a single set of spare parts suffice against the breakdown of any machine in the station, is that, from a point of view of the electrical aspect of the case, of the machines being able all to be put in parallel, as it is called. The expression may not be a familiar one to some of our readers, and the following hydraulic analogy may be of service in leading to an understanding of what is meant by it. Let us assume that we have several pumping engines of equal power, and that we are using them all to pump water from one reservoir into another at a higher level. Obviously the total amount of water pumped will be what a single machine handles multiplied by the number of them. Had, say, one of the pumps been weaker than the others—had it, that is, not been strong enough to force water up to the height that the others did—the result would be that, instead of doing any work when put, as we may say, in parallel with the others, it would have been unable to withstand the head, and water would have forced itself back through it into the lower reservoir. The same way with dynamos, or generators as they are usually called when referring to the machinery in a power as distinct from a lighting station. The advantage of working in parallel is, that if we have, say, six machines all "pumping" current into the same mains and one breaks down, we may take it out of circuit, and, by temporarily overloading the other five, which can always be done for a short time with good machines, keep on supplying full current to consumers. Should the power company have decided to put in a special machine for aluminum, and other special ones for other local work, and still more for distant work,

each would have its own circuit, and, if it broke down, the whole dependent system would be idle until repairs were completed. One of the great aims of the company appears to be to insure the permanence and continuousness of their power service—which is, of course, of the utmost importance to manufacturers.

A remarkable method of construction—not, however, unique—is employed in the generators to secure means for direct coupling to the turbine shafts. These latter are vertical, and come up over one hundred and forty feet out of the wheel pits from the rotating water wheels, which make two hundred and fifty revolutions per minute. In order to obtain direct driving—that is, without the intervention of toothed or friction gearing, or belt or rope driving—the revolving portions of the generator are arranged to rotate in a horizontal instead of, as is usual, a vertical plane.

A dynamo of any type whatever consists, as is well known, essentially of two portions, one of which possesses motion with respect to the other, viz., the armature and the field magnets. Since the field magnets are almost invariably much heavier and much less compact than the armature, the latter is usually chosen as the moving part. In the case under discussion the contrary has been decided on, the armature being fixed and the field magnets rotating. This gives certain advantages in the matter of less complicated electrical connections and of dispensing with the armature's rubbing collectors altogether; it also gives the advantage—much more important in this case than with smaller machines—that, since the revolving magnets are arranged on a ring and point inward, the attraction between them and the armature core tends toward neutralization of the strains of centrifugal force. The greatest advantage, however, attained by this method, and again one which is of far greater value in the present case than in ordinary practice, is the high degree of insulation possible with fixed armature coils and connections. The requirements that had to be met in the way of limiting the centrifugal strains were that the product of the sum of the weights of the revolving parts in pounds and the square of their velocities in feet per second should not exceed eleven hundred million. The weight of the moving parts of each dynamo was also limited to eighty thousand pounds, while the weight of the turbine and its shaft amounts to seventy-two thousand pounds.

This whole weight of seventy-six tons acts in one vertical line—i. e., that of the turbine shaft—and revolves two hundred and fifty times per minute. It would have been very difficult to construct thrust bearings to take up the whole of this strain, and a hydraulic balancing piston has been resorted to for supporting it. This device is simply a circular piston fast on the vertical turbine shaft, set in a vertical cylinder. The supporting force consists of

Fig. 4.—Commencement of Work on Slot (Wheel Pit).

hydraulic pressure admitted to the under side of the piston. This pressure is derived simply from the water in the penstock supplied to the turbine, and when the latter is working under full gate—that is, is taking water to its full capacity—the pressure in the penstock is decidedly less, just as the pressure in a water pipe is partly relieved by the opening of a faucet. This causes the supporting force on the under side of the piston to materially decrease, and a thrust bearing—that is, a bearing adapted to withstand either pressure or pull, so as to hold the shaft against the tendency to end play—has to be resorted to in order to take up the difference. As a matter of fact, the difference between the supporting force when the flow is a minimum and that when the gate is wide open is about two tons in the seventy-six. The way this is handled is to arrange the area of the piston and the depth below the upper water level so that at minimum flow the supporting pressure will be about one ton more than the total weight, and at full gate about the same amount less. At the normal rate of working there is very little to be taken up by the thrust bearings.

An idea of the magnitude of the proportions of the generators may be gathered from the fact that the designers were limited in the size of base plates that they could use by the inability of the railways to transport, even by especially large and powerful cars, pieces of proportions originally designed from the factories to he falls.

It is stated that, had it not been for the tariff restrictions imposed on the importation of electrical machinery, the generators would probably have been purchased abroad. As it was, they, as well as the motors which will operate on their circuits, are the work of a great Pittsburg company. In the case of the turbines the design was by a Geneva firm, and the construction mainly done in Philadelphia. Certain of the fittings are French, and the governors Swiss.

One of the details in the power house is a traveling crane capable of handling pieces weighing up to fifty tons, which commands every portion of the floor of the building. The presence of this piece of apparatus is of the greatest importance in the case of anything going wrong with one of the generators or turbines. With its assistance any portion of either of these ponderous pieces of mechanism which may need repair can be moved with the greatest expedition, and a spare interchangeable part put in its place. Frequently in an installation of heavy machinery, although perhaps much less ponderous than these in question, a break occurs which may cause a shut-down of many hours, when, if sufficiently powerful means of moving heavy parts were at hand, the damaged piece could be replaced in a

comparatively short time. A traveling crane of this description, as most of our readers are aware, consists of a long carriage having a pair of rails on which runs the crane truck carrying the lifting machinery. The long carriage, which is supported a suitable height above the floor, stretches across the width of space to be commanded, and itself has a sideway movement on several supporting rails which run the length of the space to be operated over. Thus by a combination of the two movements the crane truck commands the whole floor.

During the work of assembling the penstocks, wheel cases, turbines, etc., at the wheel pit, a view of this great slot with its contents was wonderfully impressive in giving an idea of the vastness of the whole enterprise. The great depth of this long, narrow pit, which made it impossible to see to the bottom except with the assistance of lamps in the lower part, the mysterious-looking pipes (the penstocks) rising vertically, new sections being constantly added much in the same way that a stovepipe is put together, except for the permanence given by the heavy riveted seams, and the enormous power and flexibility of operation of the immense traveling crane which rapidly conveyed in every direction great masses of iron and steel obedient to the turn of a switch, made a combination of impressive effects not quickly forgotten.

To obtain an idea of just what the relation to each other of the various parts in the installation is, the reader is referred to the sketches numbered 6, 7, and 8.

It may be mentioned that, to withstand the very considerable hydraulic pressure at the lower part of the penstocks, these tubes are built of thicker and thicker plates from the top downward.

There has been very little criticism of the mechanical details of construction so far referred to; on the contrary, very little can be said except in praise of the fertility of resource and high general competence of the engineers who have had this work in hand. With regard, however, to the particular design of the generators from an electrical rather than a mechanical standpoint much and lavish criticism, if not condemnation, has appeared in various quarters. Whether the grounds for this criticism are well founded or not it would be presumptuous at this time to attempt to declare, but we may say that where, as in this case, one man has had practically the entire control of the design of the electrical apparatus, we may usually look for, rather than be surprised at, a great amount of setting up of individual opinion against the views which he may embody in practice, often a good deal irrespective of the probably cogent reasons which may have induced him to adopt the course in question.

Without attempting to decide between the various views which are plentifully to hand in criticism of certain electrical

FIG. 5.—TRAVELING CRANE.

details in the design and proposed method of utilizing the current of the generators, we may glance at what has been decided on, and review the more important points raised in connection therewith.

In the first place, the use of an alternating as opposed to a direct current was decided on, as was to have been expected. The development within the last year or two of alternating-current motors has rendered possible the distribution of electricity for power (as opposed to lighting) purposes over distances before almost out of the question. It has been for a number of years past possible to transmit large quantities of electrical energy for lighting which was not suitable for running the then known motors. The method of electrical distribution for lighting purposes that is used in cities is available also for transmission to considerable distances. It consists, as is well known, of a dynamo supplying current at a high voltage to the street lines, and a system of transformers each taking a portion of this current at high voltage and giving in return a current of greater ampèrage or volume and of lower voltage for house consumption, the object being simply to avoid loss of voltage or pressure by transmitting a heavy current over a light wire. As this may not be quite clear to every reader, it may be as well to say a little more about it.

The energy of any current is determined by and is equal to the product of two of its properties, its volume or ampèrage and its pressure or voltage. Letting C represent the ampères and V the voltage, we have that the energy $= C\,V$. In passing any current over any wire there is a loss of voltage determined by and equal to the product of two things—i. e., the ampèrage of the current and the resistance of the wire; so we have loss of voltage $= C\,R$. Now, if we have two currents—one, say, of ten ampères and one volt, and the other of one ampère and ten volts—the energy will be the same, or ten watts as it is called. If we pass both through a given resistance, R, we shall have a loss of voltage ($= C\,R$) ten times greater in the first than in the second case. But a given loss of voltage amounts to only one tenth as much energy ($C\,V$) in the second case with $C =$ one ampère as it does in the first with $C =$ ten ampères, so that with only one tenth the given loss of voltage the energy lost will be only one one-hundredth that lost in the first case. What it amounts to is that the loss in passing a given amount of electrical energy through a given resistance is proportional to the square of the current, or ampèrage, and consequently inversely proportional to the square of the pressure, or voltage.

If, therefore, current is used in a house at fifty volts and transmitted to the house at one thousand volts, the loss will be

only one four-hundredth as much over a given wire as it would be if transmitted at fifty volts.

The advantage that alternating currents have over direct for long-distance transmission is that they may easily be transformed up or down—that is, their voltage at the generating end may be increased (at the expense, of course, of their ampèrage) and reduced at the consuming end. In point of fact, it is frequently and usually unnecessary to employ such devices at the generating end, for the reason that the generators themselves can work perfectly well at the high voltage requisite to transmit. The objection to using the same high voltage on the consuming machinery is simply that there is more danger of accident with numerous small motors scattered in various places and in the hands of unskilled persons than in a power station containing only two or three highly guarded machines attended by trained operatives.

With this fact of the possibility of generating currents of a voltage suitable for immediate transmission, it at first sight appears strange that direct-current transmission is not a more common thing than it is. The method of the so-called "motor transformer," "rotary transformer," or "dynamotor," might be adopted. A transmission plant working on this method would operate as follows: The power station would contain preferably several highly insulated direct-current generators, all of similar construction, for very high potential (four thousand volts would be easily obtained); these would run in series—that is, each would add its voltage to that of the others, and there would preferably be a spare machine to substitute for any one of the others which might become injured. If four machines were in series, the resultant current would be put to line at, say, sixteen thousand volts, would be received at the other end by a number of motors, also in series, which in their turn would drive low potential dynamos supplying current for local use.

There are two objections to this as compared with alternating-current transmission: One is the fact that there has grown up a very tangible, we may almost call it, superstition against the use of high-voltage direct-current machines of large size among very many electricians. The reasons for this are not difficult to trace; prominent among them being the simple fact that no commercial application has ever yet required such machines. The only high-potential direct-current dynamos are those used for arc lighting, and on account of the great subdivision of arc-lighting circuits the units of generation are invariably small, at least by comparison with the ponderous machinery used in the Niagara Falls power plant.

There is no reason why they could not be made large (in point of fact, arc-lighting requirements are continually making demands

for the construction of larger and larger machines, and the requirements are just as steadily being met without difficulty), and yet this very tangible dislike of their use for power transmission undoubtedly exists. The result is that, without undertaking considerable work on new ground in the way of patterns, designs, etc., no company could obtain such machines; and since the alternating current has had practically the exclusive attention of the laborers in the field of electrical power transmission there is no

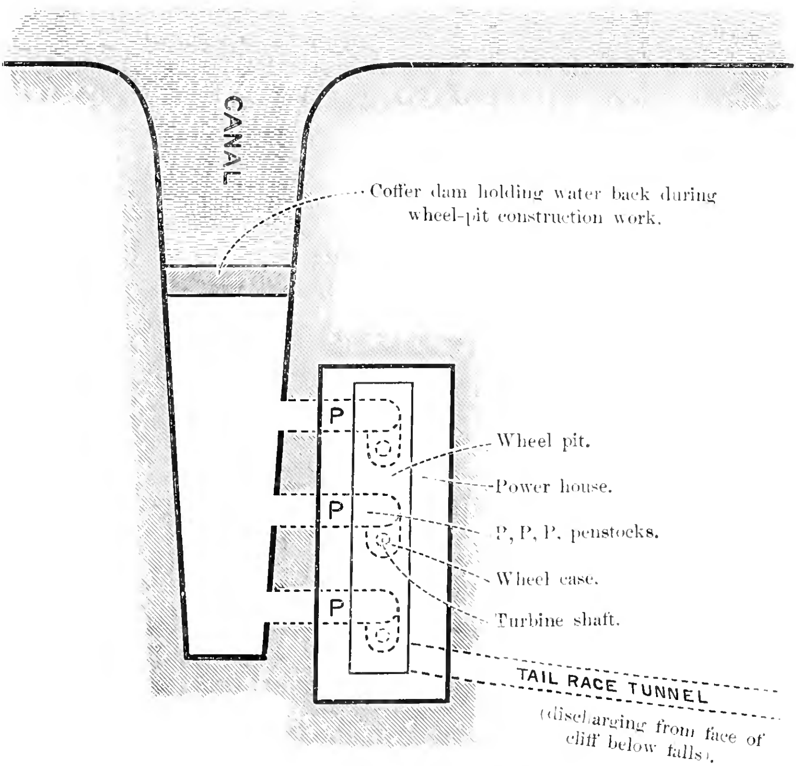

FIG. 6.—RIVER, CANAL, WHEEL PIT, AND TAIL-RACE TUNNEL.

method, tried on the large scale, for the other. The second disadvantage referred to is the greater cost of motor transformers over the simple stationary ones for alternating work. In view, however, of the fact of the proposed installation of these very motor transformers in adapting the alternating current to the arc lighting of Buffalo, and to the aluminum smelting works at Niagara, it would seem that this objection could not count for very much.

In connection with the Niagara Falls work there is the further

advantage which the alternating current has over the direct, and that is what may be termed the "flexibility," commercially, of the former. The alternating-current machines operated in parallel at, say, two thousand volts, may have a portion of their current taken from them at that voltage for use in the immediate neighborhood and the rest transformed up for distant transmission.

The advantages of the direct-current system would be two: First, the simpler methods of motor operation by its means, and the availability of the current for electrochemical work and storage-battery operation direct. Second, the smaller weight of copper necessary on the transmitting wire, for the three reasons of the evenness of flow, the absence of self-induction on the line, and the absence of skin resistance in direct-current transmission. The effects of the two latter phenomena will be discussed later.

Inventive effort has, singularly, stayed in the rut of work on alternating-current transmission, and in attempting anything on the scale of the Niagara Falls undertaking it would be perilous, even had it been considered for other reasons advisable, to depart more than necessary from usual practice.

Lately, and particularly owing to the brilliant work of a young man, a native of Smiljan Lika, a border country of Austria-Hungary, by name Nikola Tesla, there have been devised forms of apparatus, generating as well as consuming, by means of which alternating currents may be economically used for operating motors. To express it very roughly, his method amounts to arranging an armature within a magnetic ring and causing opposite magnetic poles to revolve around the ring so as to cause rotation of the armature.

The operation of these devices is preferably by means of a polyphase alternating current—that is, a flow of electricity having more than one pulsating current.

Before finally deciding on what system of transmission to use, the Cataract Construction Company asked for plans for a system for the purpose from a number of electrical engineering establishments. Twenty-four distinct ones were submitted, more than one of the tendering companies having sent several different plans to be chosen from. No individual one was, however, accepted *in toto*, but instead a design was adopted embodying such points of value as could be assembled in one suitable type of machine, and the Westinghouse Company received the contract for it. The system on which the generators work is the Tesla two-phase, and is notably peculiar on account of the low periodicity of alternation.

The number of pulsations of commercial alternating currents is usually over one hundred per second and is frequently double

that amount. The reasons for this high frequency are mainly two: The first, that with any given alternating-current dynamo the number of alternations depends directly on the speed, and, as this must usually be high in order to get as much work as possible out of the machine, the periodicity is also high. The second reason is that in lighting work it is, of course, highly undesirable to employ a current of which the pulsations are so slow as to leave the incandescent filament or the arc visibly dimmer between separate beats, as we may call them, than during the passage of the full current strength. In the case in hand one is impressed with the effort that has been made to steer a middle course in the design of the generators so as to obtain a portion of

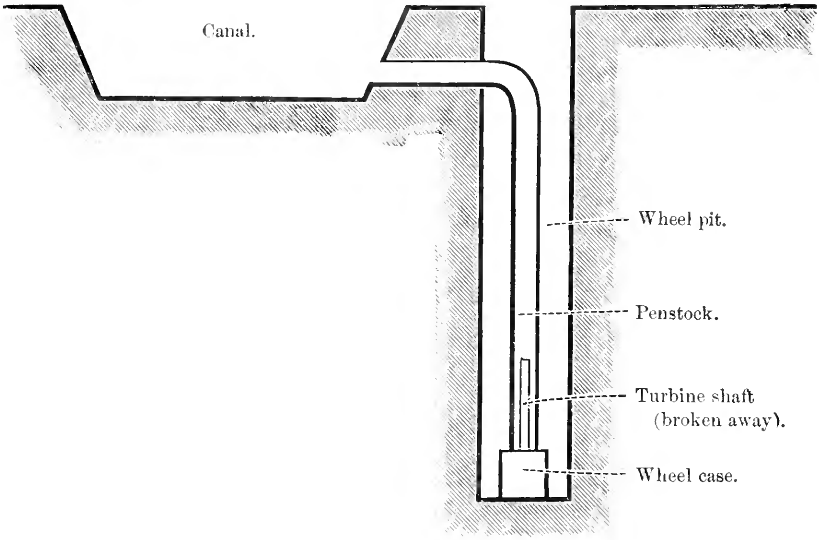

Fig. 7.—Elevation (part section) of Wheel Case, Pit, and Penstock.

the advantage of the direct current for motor work and of the alternating for transformation. The periodicity for the first portion at least of the electrical equipment is to be as low as twenty-five per second, and this at once limits the scope of the use of the current in the matter of electric lighting. Prof. Forbes states that lighting by the current direct is a comparatively small portion of the work in contemplation, and that the plant is rather to be regarded as essentially for power distribution. The expression, "lighting by the current direct," is used because a very important branch of the power work will be the lighting of the city of Buffalo. This is at present done by the ordinary direct-current arc machines operated by engines of some three thousand horse power. In changing over to the Niagara Falls power the whole

electrical system will be untouched, but the engines will be replaced by motors operated by current from the falls station.

As has been justified by the importance of the subject, there have been some quite exhaustive experiments undertaken by various scientists to determine the frequency of alternation at which unsteadiness of the light from both incandescent and arc lamps is observable or at least objectionable. Several independent experimenters have arrived at results sufficiently satisfactory to themselves, but which unfortunately can not be used as reliable data, for the reason that they are highly discrepant with each other. One reason for this is the evident one of the difference between different makes of lamps, but the discrepancies are of a character not altogether to be explained on that ground. With the ordinary fifty-volt filament, however, it would seem that we may place the working rate of alternation at about thirty or over; with arc lamps, at about fifty or over.

As above mentioned, the arc lighting will be done by making use of the motor transformer (a motor operated by the power current driving a dynamo generating, if we may call it so, the secondary current), but it is expected that by means of a special form of incandescent lamp—the Bernstein, which has, indeed, been on the market for several years—the twenty-five-period current will be available for direct use for illumination by means of incandescent lamps. It is evident that the thicker the filament the longer will its incandescence take to die out (as well as to start up), and a current of twenty-five pulsations, which may not be available for the high-resistance (thin) filament, may be quite sufficiently so for a low-resistance one, which the Bernstein lamp above mentioned is.

The voltage at which the first installation of generators is to operate is somewhat over two thousand. Considering the perfection to which European practice has been carried in the construction of alternating-current machines for much higher electrical pressures than the above, it seems strange that this voltage should have been decided on in a situation where one would expect the very highest degree of perfection to be attained. It is stated, however, that it was largely on account of the comparatively backward condition of that branch of electrical engineering construction in America that the voltage had to be placed so low.

In a case like the present one, where the power station will be under the supervision of skilled engineers, and not merely of men whose chief qualifications are those of sobriety and an ability to stay awake at night, there appears no sufficient reason why the generators should not be operated at five times the voltage named. The fact of the armatures in these machines being fixed gives, moreover, additional security against danger consequent on such

high voltage on account of the very much more perfect insulation possible.

The advantage, of course, of using a very high electrical pressure lies in the principle stated above of the loss in sending a given amount of energy over a given wire being inversely proportional to the square of the voltage.

By the use of step-up transformers it will, of course, be possible to transmit at any voltage that the insulation of the line can withstand; but if this high voltage could be reached by the machines directly, the loss (we may liken it to a friction loss in machinery) of efficiency in the transformers, and, even more important, the great cost of that part of the equipment, would both be avoided.

What will be done will be to use these step-up transformers and put current on the transmitting line at about twenty thousand volts; it is likely, however, that in any subsequent enlargements of the generating plant the three original machines will be used for local work only, and a radical change made in the direction of an enormously higher generated voltage.

Intimately associated with this question is the problem of how to convey current at this tremendous potential of twenty thousand volts to distances. An idea of what it means may be had from the facts that two thousand is relied on to be sufficient to instantly kill a human being, and that the energy of a current given up in passing through any given resistance varies as the square of the voltage.

The chief difficulty to be met in such line construction is that of efficiently insulating the wires. If one attempted to use a line insulated merely as an ordinary telegraph line is, there would be an enormous loss, amounting practically to the whole of the transmitted current, in moist weather, by leakage over the damp surfaces of the glass or other insulators. The remedy for this leakage would, however, be a comparatively simple matter by means of well-known oil-holding arrangements for the insulators were it not for the further fact that it is imperatively necessary not to have the two wires, the going and return ones, farther apart than can not be avoided on account of what are known as the effects of self-induction. The wires strung on telegraph poles would have to be so far apart in order to insure their never, by any possibility, coming in contact, that the self-induction losses would make that method impracticable.

The self-induction of a circuit has the effect of retarding both the starting up and the dying out of a current flowing in the circuit. The phenomenon gives a resemblance of the possession of a property analogous to mechanical inertia to the current. Since inertia, however, is a property dependent solely on the mass of a

body, and is the same for all situations or conditions of the body, we shall see that self-induction has but a very faint likeness to it, for self-induction is a property of a conducting path or circuit, and not at all of the current. To dip lightly into the theory of the phenomenon, we may say that the inception or the stoppage of an electrical flow in any conductor involves the starting up or stoppage of a movement in the dielectric medium surrounding the conductor. The time requisite for this movement to start up or stop gives a perfect analogue to mechanical inertia. If, now, we have a circuit consisting of a wire returning on itself, the two halves being as close together as they may be without touching, we see that a flow starting up in this wire means a current in each half in opposite directions. For the present it suffices to say that the effect above referred to of the starting up of a movement in the surrounding medium is rendered less and less by the canceling effect of the opposite electrical flows the nearer the two halves of the circuit are brought together.

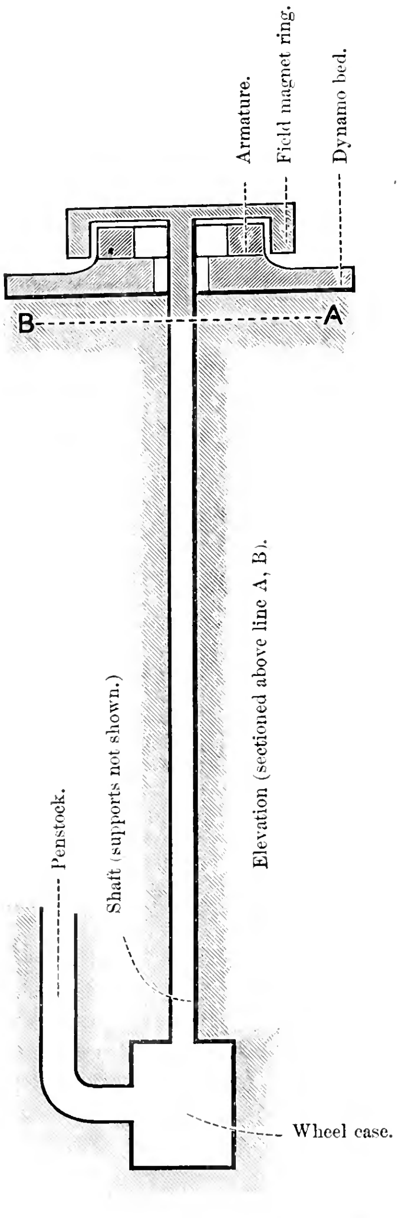

Fig. 8.—Wheel Case, Shaft, and Dynamo.

The evil effects of self-induction are directly proportional to the number of alternations of the current in a given time, and consequently the twenty-five-period current adopted for the Niagara Falls work is highly advantageous from this point of view.

The so-called "skin resistance" of an alternating-current circuit is, in brief, due to the fact that an alternating current penetrates only a short distance into

the body of the metal of which the carrying wire is composed, instead of, as in the case of a direct current, flowing across the whole cross-section of the wire in an even manner. This also is less serious the lower the periodicity. In the case of a lightning flash (which is an alternating-current discharge) the periodicity is enormously high, and it is known that in its flow over wires it travels almost entirely through the mere surface skin of the metal. It may be mentioned here, as having possibly a very important bearing on work such as that under discussion, that a most remarkable claim has recently been brought forth that bi-metallic wires, or wires of one metal coated with a different one on the outside, give remarkably improved results for the conduction of alternating currents over the conductivities of the two metals in the weights used, laid together as separate wires.

The form decided on in which to construct the conveying lines is that of a conduit or subway of large proportions. One which has been already constructed for a length of half a mile is as follows: The walls are arched, and the width is greatest at about two thirds of the height. The conductors are carried on insulated brackets along the sides, spaced at intervals of thirty feet. The subway is lined with concrete, and manholes at intervals allow of access; besides, there are small pieces of pipe let in at the bottoms of the manhole ducts for the purpose of inserting such wires as may from time to time be required to tap the line conductors. The subway is five and a half feet high and three feet ten inches wide. A track runs along it, and the line inspectors will make their trips on an electrically propelled car; heavy wire screens the height of the subway, extending on both sides of the track, protecting the occupants from any possible discharge from the main conductors.

The Cataract Construction Company expect to be able to deliver power in Buffalo at a cost per horse power, for twenty-four hours a day yearly, greatly below the cost of steam power as now produced in Buffalo with coal at one dollar and a half per ton. The generators are expected to operate at five thousand horse power each, with an efficiency of ninety-eight per cent on the power delivered to them by the turbines, and there will be only three and a half per cent drop of pressure in transmitting at twenty thousand volts to the northern part of Buffalo. This last appears wonderful when we consider that it is less than the drop from the generators of an electric railway system to the motors of cars within as short a distance as half a mile, quite apart, moreover, from the extra losses in the latter case due to imperfect trolley contacts. It is hoped also to transmit power before long to the Erie Canal, on which at the close of last season there was an interesting development in the line of electrical

canal-boat propulsion. What else may be in store for the closing years of the century in still further applications of transmitted electrical power, notably in the displacement of steam in railroad operation, can only be foreshadowed. Suffice it to say that the Niagara Falls Power Company will probably soon find their initial fifteen thousand horse-power equipment entirely insufficient to meet the demands upon it.

SCIENTIFIC EDUCATION.*

By Dr. H. E. ARMSTRONG, F. R. S.

ENGLISH boys and girls at the present day are the victims of excessive lesson learning, and are also falling a prey, in increasing numbers year by year, to the examination-demon, which threatens to become by far the most ruthless monster the world has ever known either in fact or in fable. Ask any teacher who has to do with students fresh from school his opinion of them: he will say that in the great majority of cases they have little if any power of helping themselves, little desire to learn about things, little if any observing power, little desire to reason on what they see or are called on to witness; that they are destitute of the sense of accuracy, and satisfied with any performance, however slovenly; that, in short, they are neither inquisitive nor acquisitive, and as they too often are idle as well, the opportunities offered to them are blindly sacrificed. A considerable proportion undoubtedly are by nature mentally very feeble; but the larger number are by no means without ability, and are, in fact, victims of an acquired disease. We *must* find a remedy for this state of things, or perish in the face of the terrific competition now setting in. Boys and girls at school must be taught from the very earliest moment to *do* and to *appreciate*. It is of no use our teaching them merely *about* things, however interesting—no facts must be taught *without their use* being taught simultaneously; and, as far as possible, they must be led to discover the facts for themselves. Instead of our placing condensed summaries in their hands, we must lead them to use works of reference and acquire the habit of finding out; they must always be at work applying their knowledge and solving problems. It is a libel on the human race to say, as many do, that children can not think and reason, and that they can only be taught facts; early childhood is the time at which these faculties are most apparent, and it is probably

* From the Presidential Address delivered at the Chemical Society (Great Britain), on March 22, 1894.

through failure to exercise them then that they suffer atrophy. The so-called science introduced into a few schools in answer to the persistent demands of its advocates has been in most cases a shallow fraud, of no value whatever educationally. Boys see oxygen made and things burned in it, which gives them much pleasure; but, after all, this is but the old lesson learning in an interesting shape, and has no superior *educational* effect. I would here repeat what I have recently urged elsewhere, that in the future *all subjects* must be taught *scientifically* at school, in order to inculcate those habits of mind which are termed scientific habits; the teaching of *scientific method*—not the mere shibboleths of some branch of natural science—must be insisted on. No doubt some branch of chemistry, with a due modicum of physics, etc., is the subject by means of which we may best instill the scientific habits associated with experimental studies, but it must be the true chemistry of the discoverer, not the cookery-book-receipt pseudo-form which has so long usurped its place. Whatever be taught, let me repeat that mere repetition work and lesson learning *must* give place to a system of allowing children to *do* things themselves. Should we succeed in infusing the research spirit into our teaching generally, then there will be hope that, in the course of a generation or so, we shall cease to be the Philistines we are at the present time; the education given in our schools will be worthy of being named a "*liberal education*," which it never will be so long as we worship the old world classical fetich, and allow our schools to be controlled by those who reverence this alone, having never been instructed in a wider faith.

As regards our college courses, I see no reason to modify the views expressed in my address to the Chemical Section of the British Association at Aberdeen in 1885; on the contrary, the experience I have since gained as a teacher and examiner has served only to strengthen them and to convince me of the paramount necessity of a very radical change in our system of instruction, and I rejoice at the increasing evidence of a state of unrest both at home and abroad. The "thorough" course of qualitative analysis which it has long been customary to impose at a very early period of the student's career must, I venture to think, be relegated to near its close; this course certainly has not the effect of producing competent analysts, and but too often reduces those who toil through it to the dead level of machines; in hundreds of cases I have seen students, as it were, hang up their intelligence on the clothes peg outside and enter the examination room masked with a set of analytical tables, through which alone they allow themselves to be actuated, and to which they render the blindest obedience. Qualitative analysis actually requires the fullest exercise of the mental faculties as well as considerable manip-

ulative skill. By introducing this branch of study at too early a period we force our students to act as machines, inasmuch as they do not, and can not, know enough to work intelligently; we are but trying to make them run before they have learned to walk. Even when the interactions on which qualitative analysis is based are fully studied, and the equations relating thereto are conscientiously written out, the result is not much better, owing to the slight importance of so many of the interactions apart from their technical application in analysis, and especially on account of our ignorance of the precise nature of many of the interchanges of which we avail ourselves: the persistent misrepresentation of facts which such a course encourages is, in my opinion, one of its worst features.

I believe that in the near future our students will first be set to solve problems, each in its way a little research, and involving much simple quantitative work; they will thus be taught chemical method, or, in other words, *the art of discovery*. They will then be taken through a course of quantitative exercises with the object of making them acquainted, by direct contact with the facts, with the fundamental principles of our science, which are but too rarely appreciated at the present day. After this, they will seek to acquire proficiency in quantitative analysis and in the art of making preparations; and subsequently they will give sufficient attention to the study of physical properties to enable them to appreciate the physico-chemical methods of inquiry which are now of such importance. The study of qualitative analysis in detail will be left to the last, as being an eminently technical subject. Meanwhile, by attendance at lectures, by reading carefully chosen works of a kind altogether different from the soul-destroying text-books we now possess, and especially by the study of classical models in chemical literature, they will have acquired what is commonly spoken of as theoretical knowledge, but too often regarded by us as of secondary importance, and which it is so difficult to make Englishmen realize means a proper understanding of the subject. Students so trained—imbued from the outset, even from early school days, with the research spirit—will at all times be observant and critical, nay, even logical; dogmatic teaching will cease to have any charm for them: they will actually take deep interest in their studies—a result devoutly to be hoped for, as nothing is more galling to the teacher at the present day than the crass indifference of the average student and his refusal to give attention to anything unless it will pay in an examination. At the close of such a course the student will be thoroughly prepared to undertake original investigation, distinctly with the object of exhibiting his individuality and originality, and not, as at present, with the object of

acquiring for the first time an insight into the methods of the investigator; he will thus be spared the unpleasant discovery which the advanced student now too often makes that his early training has unfitted him, rather than prepared him, for the task of original inquiry.

Much to be feared, also, is the tendency to overestimate the value of examinations, and the great work of the future will be so to improve these that they shall have no prejudicial influence on the student's work and in no way check the development of original methods of teaching; we must fix our attention mainly on the influences to which the student is to be subjected during his career; the competent teacher will ever study his students while they are at work, and do the best for them, provided he be not rendered powerless by the trammels of an examination system which heeds "results" only and not individuals.

Finally, let me say that, while sympathizing most fully with those who advocate a complete course of study, I feel that it is very easy to demand too much—very easy to make it impossible for students to do justice to their work by imposing too many subjects. Our chief desire must always be that students shall acquire a knowledge of scientific method and the power of working independently. Certain subjects must be insisted on—for example, mathematics and drawing—if a knowledge of these be not acquired early it will never be acquired; but apart from these and a competent knowledge of the main subject, we probably may, as a rule, be satisfied with comparatively little. Those who have once learned to work and acquired a knowledge of scientific method will, of their own accord, in proportion to their intelligence, apply themselves also to the study of other subjects—as many among us have done; those who are not sufficiently intelligent to do this are not, as a rule, improved by being forced to pay attention to unpalatable studies; on the contrary, they are, more often than not, thereby hindered from acquiring a competent knowledge of some one subject which does appeal to them, and are spoiled for life in consequence.—*Reprinted from Nature.*

The studies of Dr. R. W. Shufeldt have led him to believe that the art of taxidermy has had an evolutionary growth peculiarly its own, and that of recent years the strong tendency in the leading museums has been to group animals, and for a variety of purposes. The author is convinced that in the future museums will carry this idea still further, and that the groups will be so combined as to exhibit, besides single species, showing some of their habits and surroundings in their natural haunts, also to a large extent faunal regions, and the animal and plant life of various geographical areas. By such arrangements the eye will be enabled to take in and the mind appreciate the aspect and the biologic forms of any particular region of the United States almost at a glance.

ETHICAL RELATIONS BETWEEN MAN AND BEAST.

By Prof. E. P. EVANS.

ETHNOCENTRIC geography, which caused each petty tribe to regard itself as the center of the earth, and geocentric astronomy, which caused mankind to regard the earth as the center of the universe, are conceptions that have been gradually outgrown and generally discarded—not, however, without leaving distinct and indelible traces of themselves in human speech and conduct. But this is not the case with anthropocentric psychology and ethics, which treat man as a being essentially different and inseparably set apart from all other sentient creatures, to which he is bound by no ties of mental affinity or moral obligation. Nevertheless, all these notions spring from the same root, having their origin in man's false and overweening conceit of himself as the member of a tribe, the inhabitant of a planet, or the lord of creation.

It was upon this sort of anthropocentric assumption that teleologists used to build their arguments in proof of the existence and goodness of God as shown by the evidences of beneficent design in the world. All their reasonings in support of this doctrine were based upon the theory that the final purpose of every created thing is the promotion of human happiness. Take away this anthropocentric postulate, and the whole logical structure tumbles into a heap of unfounded and irrelevant assertions leading to lame and impotent conclusions.

Thus Bernardin de Saint-Pierre states that garlic, being a specific for maladies caused by marshy exhalations, grows in swampy places, in order that the antidote may be easily accessible to man when he becomes infected with malarious disease. Also the fruits of spring and summer, he adds, are peculiarly juicy, because man needs them for his refreshment in hot weather; on the other hand, autumn fruits, like nuts, are oily, because oil generates heat and keeps men warm in winter. It is for man's sake, too, that in lands where it seldom or never rains there is always a heavy deposition of dew. If we can show that any product or phenomenon of Nature is useful to *us*, we think we have discovered its sufficient *raison d'être*, and extol the wisdom and kindness of the Creator; but if anything is harmful to us we can not imagine why it should exist. How much intellectual acuteness and learning have been expended to reconcile the fact that the moon is visible only a very small part of the time, with the theory that it was intended to illuminate the earth in the absence of the sun, for the benefit of its inhabitants!

Gennadius, a Greek presbyter, who flourished at Constantino-

ple about the middle of the fifth century remarks in his commentary on the first chapter of Genesis, that God created the beasts of the earth and the cattle after their kind on the same day on which he created man, in order that these creatures might be there ready to serve him.

But it would be superfluous to multiply examples of the influence of this anthropocentric idea as it has worked itself out in the history of mankind. Every science has had to encounter its opposition, and it has been a stumbling-block in the way of every effort to enlarge human knowledge and to promote human happiness. It has tended to check the progress of hygienic research and sanitary reform; for if man is of such exceptional importance that his conduct or misconduct can bring down epidemics upon whole communities and vast continents as visitations of divine wrath, whoever seeks to ward off or to stay these punishments is guilty of a sacrilegious attempt to parry the blow aimed at the wicked by the arm of the Almighty, and, by thus setting himself in antagonism to God, becomes in fact an ally and adversary of the devil. Thus vaccination was denounced, not on the ground taken by its present opponents, that it is useless as a preventive of smallpox and a prolific source of other diseases, but on account of its real or supposed prophylactic effectiveness, since it impiously wrenched from the hand of the Deity one of his most fatal weapons of retribution.

To what absurdities of presumption the anthropocentric conception has paved the way is evident from the belief, once universally entertained, that the sun, moon, and stars were placed in the firmament with express reference to man, and exerted a benign or baleful influence upon his destiny from the cradle to the grave. Owen Glendower's bombastic boast—

> ". . . At my nativity
> The front of heaven was full of fiery shapes,
> Of burning cressets; and at my birth
> The frame and huge foundation of the earth
> Shaked like a coward"—

was well answered by Hotspur: "Why, so it would have done at the same season if your mother's cat had but kittened, though yourself had ne'er been born." And yet this fulsome brag of the Welsh swashbuckler was only an extravagant statement of what the captious Henry Percy and his contemporaries all held to be virtually true. Poe embodies the same sentiment in his youthful poem, Al Aaraaf, and would fain preserve this brighter world of his fancy from the contagion of human evil—

> "Lest the stars totter in the guilt of man."

Astrology and horoscopy, from which even the keen intellects of Kepler and Tycho de Brahe could not disentangle themselves, and to which the still more modern genius of Goethe paid a characteristic tribute in the story of his nativity, were only this anthropocentric conceit masquerading as science, and leaving vestiges of itself in such common words as "ill-starred" and "lunatic."

Comets were universally regarded as portents of disasters, sent expressly as warnings for the reproof and reformation of mankind; tempests and lightnings were feared as harbingers of divine wrath and instruments of punishment for human transgression. According to the Rev. Increase Mather, God took the trouble to eclipse the sun in August, 1672, merely to prognosticate the death of the President of Harvard College and of two colonial governors, all of whom "died within a twelvemonth after." This is but a single example of the wide prevalence and general acceptance of a popular superstition constantly tested and easily proved by the logical fallacy *post hoc ergo propter hoc.* Bayle, in his Divers Thoughts on Comets (*Pensées Diverses sur les Comètes*), ridicules the foolish pride and vanity of man, who imagines that "he can not die without disturbing the whole course of Nature and compelling the heavens to put themselves to fresh expense in order to light his funeral pomp."

Not only were the fruits of the earth made to grow for human sustenance, but the flowers of the field were supposed to bud and blossom, putting on their gayest attire and emitting their sweetest perfume, solely as a contribution to human happiness; and it was deemed one of the mysteries and mistakes of Nature, never too much to be puzzled over and wondered at, that these things should spring up and expend their beauty and fragrance in remote places untrodden by the foot of man. Gray expresses this feeling in the oft-quoted lines:

> "Full many a flower is born to blush unseen,
> And waste its sweetness on the desert air."

Science has finally and effectually taken this conceit out of man by showing that the flower blooms not for the purpose of giving him agreeable sensations, but for its own sake, and that it presumed to put forth sweet and beautiful blossoms long before he appeared on the earth as a rude cave-haunting and flint-chipping savage.

The color and odor of the plant are designed not so much to please man as to attract insects, which promote the process of fertilization and thus insure the preservation of the species. The gratification of man's æsthetic sense and taste for the beautiful does not enter into Nature's intentions; and although the flower may bloom unseen by any human eye, it does not on that ac-

count waste its sweetness, but fully accomplishes its mission, provided there is a bee or a bug abroad to be drawn to it. That the fragrance and variegated petals are alluring to a vagrant insect is a condition of far more importance in determining the fate of the plant than that they should be charming to man.

Plants, on the other hand, which depend upon the force of the wind for fructification, are not distinguished for beauty of color or sweetness of odor, since these qualities, however agreeable to man, would be wasted on the wind. This is an illustration of the prudent economy of Nature, which never indulges in superfluities or overburdens her products with useless attributes; but the test of utility which "great creating Nature" sets up in such cases is little flattering to man, and has no reference to his tastes and susceptibilities, but is determined solely by the serviceableness of certain qualities of the plant itself in the struggle for existence.

According to Schopenhauer, anthropocentric egoism is a fundamental and fatal defect in the psychological and ethical teachings of both Judaism and Christianity, and has been the source of untold misery to myriads of sentient and highly sensitive organisms. "These religions," he says, "have unnaturally severed man from the animal world, to which he essentially belongs, and placed him on a pinnacle apart, treating all lower creatures as mere things; whereas Brahmanism and Buddhism insist not only upon his kinship with all forms of animal life, but also upon his vital connection with all animated Nature, binding him up into intimate relationship with them by metempsychosis."

In the Hebrew cosmogony there is no continuity in the process of creation, whereby the genesis of man is in any wise connected with the genesis of the lower animals. After the Lord God, by his fiat, had produced beasts, birds, fishes, and creeping things, he ignored all this mass of protoplastic and organic material, and took an entirely new departure in the production of man, whom he formed out of the dust of the ground. Science shows him to have been originally a little higher than the ape, out of which he was gradually and painfully evolved; Scripture takes him out of his environment, severs him from his antecedents, and makes him a little lower than the angels. Upon the being thus arbitrarily created absolute dominion is conferred over every beast of the earth and every fowl of the air, which are to be to him "for meat." They are given over to his supreme and irresponsible control, without the slightest injunction of kindness or the faintest suggestion of any duties or obligations toward them.

Again, when the earth is to be renewed and replenished after the deluge, the same principles are reiterated and the same line of demarcation is drawn and even deepened. God blesses Noah and his sons, bids them "be fruitful and multiply," and then adds, as

regards the lower animals: "The fear of you and the dread of you shall be upon every beast of the earth and upon every fowl of the air, upon all that moveth upon the earth, and upon all the fishes of the sea; into your hand are they delivered. Every moving thing that liveth shall be meat for you; even as the green herb have I given you all things."

This tyrannical mandate is not mitigated by any intimation of the merciful manner in which the human autocrat should treat the creatures thus subjected to his capricious will. On the contrary, the only thing that he is positively commanded to do with reference to them is to eat them. They are to be regarded by him simply as food, having no more rights and deserving no more consideration as means of sating his appetite than a grain of corn or a blade of grass.

The practical working of this decree has been summed up by Shelley, with his wonted force and succinctness, when he says, "The supremacy of man is, like Satan's, a supremacy of pain." Burns regrets the fatal effect of the sovereignty thus conferred upon the human race in destroying the mutual sympathy and confidence which should exist between the lord of creation and the lower animals in the lines addressed To a Mouse, on turning her up in her Nest with the Plow, November, 1785:

> "I'm truly sorry man's dominion
> Has broken Nature's social union,
> An' justifies that ill opinion
> Which makes thee startle
> At me, thy poor earth-born companion,
> An' fellow-mortal."

In the subsequent annals of the world we have ample commentaries on this primitive code written in the blood of helpless, innocent, and confiding creatures, which, although called dumb and incapable of recording their sufferings, yet

> " . . . have long tradition and swift speech,
> Can tell with touches and sharp-darting cries
> Whole histories of timid races taught
> To breathe in terror by red-handed man."

Indeed, ever since Abel's firstlings of the flock were more acceptable than Cain's bloodless offerings of the fruits of the fields, priests have performed the functions of butchers, converting sacred shrines into shambles in their endeavors to pander to the gross appetites of cruel and carnivorous gods. Cain's offering was rejected, says Dr. Kitto, because "he declined to enter into the sacrificial institution." In other words, he would not shed the blood of beasts to gratify the Lord—a refusal which we

can not but regard as exceedingly commendable in Adam's first-born.

"I do not remember," observed Mrs. Jameson, "ever to have heard the kind and just treatment of animals enforced on Christian principles or made the subject of a sermon." George Herbert was a man of gentle spirit and ready hand for the relief of all forms of human distress, and in his book entitled A Priest to the Temple, or the Country Parson, lays down rules and precepts for the guidance of the clergyman in all relations of life, even to the minutest circumstances and remotest contingencies incident to parochial care. But this tender-hearted man does not deem it necessary for the parson to take the slightest interest in animals, and does not utter a word of counsel as to the manner in which his parishioners should be taught their duties toward the creatures so wholly dependent upon them. Indeed, no treatise on pastoral theology ever touches this topic, nor is it ever made the theme of a discourse from the pulpit, or of systematic instruction in the Sunday school.

Neither the synagogue nor the church, neither sanhedrin nor ecclesiastical council, has ever regarded this subject as falling within its scope, and sought to inculcate as a dogma or to enforce by decree a proper consideration for the rights of the lower animals. One of the chief objections urged by Celsus more than seventeen centuries ago against Christianity was that it "considers everything as having been created solely for man." This stricture is indorsed by Dr. Thomas Arnold, of Rugby, who also animadverts on the evils growing out of the anthropocentric character of Christianity as a scheme of redemption and a system of theodicy. "It would seem," he says, "as if the primitive Christian, by laying so much stress upon a future life in contradistinction to this life, and placing the lower creatures out of the pale of hope, placed them at the same time out of the pale of sympathy, and thus laid the foundation for this utter disregard of animals in the light of our fellow-creatures. The definition of virtue among the early Christians was the same as Paley's—that it was good performed for the sake of insuring eternal happiness—which of course excluded all the so-called brute creatures. Kind, loving, submissive, conscientious, much-enduring, we know them to be; but because we deprive them of all stake in the future, because they have no selfish, calculated aim, these are not virtues; yet if we say 'a vicious horse,' why not say 'a virtuous horse'?"

We are ready enough, adds Dr. Arnold, to endow animals with our bad moral qualities, but grudge them the possession of our good ones. The Germans, whose natural and hereditary sympathy with the brute creation is stronger than that of any other West-

ern people, speak of horses as "*fromm*," pious, not in the religious, but in the primary and proper sense of the word, meaning thereby kind and docile. The English "gentle" and the French "*gentil*," which are used in the same connection, refer to good conduct as the result of fine breeding.

Archdeacon Paley's definition of virtue, to which Dr. Arnold adverts, is essentially anthropocentric and intensely egoistic. "Virtue," he says, "is the doing good to mankind in obedience to the will of God, for the sake of everlasting happiness." In order to be virtuous, according to this extremely narrow and wholly inadequate conception of virtue, we must, in the first place, do good to mankind, our conduct toward the brute creation not being taken into the account; secondly, our action must be in obedience to the will of God, thus ruling out all generous impulses originating in the spontaneous desire to do good; thirdly, we must have an eye single to our own supreme personal advantage—in other words, our conduct must be utterly selfish, spring not merely from momentary pleasure or temporary profit, but from far-seeing calculations of the effect it may have in securing our eternal happiness. Thus the virtuous man becomes the incarnation of the intensest self-love and self-seeking, and virtue the synonym of excessive venality. From a moral point of view, there is no greater merit in "otherworldliness" than in worldliness, and no reason why the endeavor to attain personal happiness in a future life should differ in quality from the effort to make everything minister to our personal happiness in the present life.

"The whole subject of the brute creation," says Dr. Arnold, "is to me one of such painful mystery that I dare not approach it." The mental distress experienced in such cases arises from the fact that the subject is approached from the wrong side and surveyed from a false point of view. Traditional theology and anthropocentric ethics are brought into conflict with the better impulses of a broad and generous nature and the sharp antagonism could hardly fail to be a source of perplexity and pain. "Charity," says Lord Bacon, "will hardly water the ground, where it must first fill a pool"; and of all pools the hardest to fill is that which is dug in the dry, gravelly soil of human egotism.

Theocritus, the father of Greek idyllic poetry, represents Hercules as exclaiming, after he had slain the Nemean lion, "Hades received a monster soul"; and he saw nothing incongruous in the spirit of the dead beast joining the company of the departed spirits of men in the lower world. Sydney Smith says, in speaking of the soul of the brute, "To this soul some have impiously allowed immortality." Why such a belief should be deemed impious it is difficult to discover. The question which the psychol-

ogist has to consider is not whether the doctrine is impious, but whether it is true. No scientific opinion has ever been advanced that has not seemed impious to some minds, and been denounced and persecuted as such by ecclesiastical authorities.

Bishop Butler, on the contrary, in his work on The Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature, declares that "we can not find anything throughout the whole analogy of Nature to afford us even the slightest presumption that animals ever lose their living powers." He admits that his argument in support of the doctrine of a future life proves the immortality of brutes as well as that of man, and thus recognizes their spiritual kinship.

An eminent Scotch physician and anatomist, Dr. John Barclay, in his Inquiry into the Opinions, Ancient and Modern, concerning Life and Organization (1825), urges the probable immortality of the lower animals, which, he thinks, are "reserved, as forming many of the accustomed links in the chain of being, and by preserving the chain entire, contribute in the future state, as they do here, to the general beauty and variety of the universe, a source not only of sublime but of perpetual delight." The author seems to infer the continued existence of the brute creation from the fact that it forms an essential part of universal being, and that its total disappearance would mar the perfection of the next world, which should be more perfect than this world. He assumes, however, that the lower animals are endowed with immortality, not so much from psychological necessity or for their own sake as sentient and intelligent creatures, as for man's sake, in order that their presence may minister to his pleasure by forming an attractive feature in the heavenly landscape. It is, therefore, solely from anthropocentric considerations that they are granted this lease of eternal life; just as "the poor Indian" is represented by the poet as looking forward to the possession of happy hunting fields after death, where he may follow with keener enjoyment his favorite pursuit, and "his faithful dog shall bear him company."

More than fifty years ago Henry Hallam made the following observations, which are remarkable as an anticipation of the ethical corollary to the doctrine of evolution: "Few at present, who believe in the immortality of the human soul, would deny the same to the elephant; but it must be owned that the discoveries of zoölogy have pushed this to consequences which some might not readily adopt. The spiritual being of a sponge revolts a little our prejudices; yet there is no resting place, and we must admit this or be content to sink ourselves into a mass of medullary fiber. Brutes have been as slowly emancipated in philosophy as some classes of mankind have been in civil polity; their

souls, we see, were almost universally disputed to them at the end of the seventeenth century, even by those who did not absolutely bring them down to machinery. Even within the recollection of many, it was common to deny them any kind of reasoning faculty, and to solve their most sagacious actions by the vague word instinct. We have come in late years to think better of our humble companions; and, as usual in similar cases, the preponderant bias seems rather too much of a leveling character." During the half century that has elapsed since these words were written, not only has zoölogy made still greater progress in the direction indicated, but a new science of zoöpsychology has sprung up, in which the mental traits and moral qualities of the lower animals have been, not merely recorded as curious and comical anecdotes, but systematically investigated and philosophically explained. In consequence of this radical change of view, human society in general has become more philozoic, not upon religious or sentimental but upon strictly scientific grounds, and developed a sympathy and solidarity with the animal world, having its sources less in the tender and transitory emotions of the heart than in the profound and permanent convictions of the mind.

In an essay published a few years ago in The Dublin Review (October, 1887, p. 418), the Right Rev. John Cuthbert Hedley, Bishop of Newport and Menevia, asserts that animals have no rights, because they are not rational creatures and do not exist for their own sake. "The brute creation have only one purpose, and that is to minister to man, or to man's temporary abode." This is the doctrine set forth more than six centuries ago by Thomas Aquinas, and recently expounded by Dr. Leopold Schutz, professor in the theological seminary at Treves, in an elaborate work entitled The So-called Understanding of Animals or Animal Instinct. This writer treats the theory of the irrationality of brutes as a dogma of the Church, denouncing all who hold that the mental difference between man and beast is one of degree, and not of kind, as "enemies of the Christian faith"; whereas those who cling to the old notion of instinctive or automatic action in explaining the phenomena of animal intelligence are extolled as "champions of pure truth."

If it was the Creator's intention that the lower animals should minister to man, the divine plan has proved to be a failure, since the number of animals which, after centuries of effort, he has succeeded in bringing more or less under his dominion is extremely small. Millions of living creatures fly in the air, crawl on the earth, dwell in the waters, and roam the fields and the forests, over which he has no control whatever. Not one in twenty thousand is fit for food, and of those which are edible he does not actually eat more than one in ten thousand. In explana-

tion of this lack of effectiveness in the enforcement of a divine decree, it has been asserted that man lost his dominion over the lower world to a great extent when he lost dominion over himself; but this view is wholly untenable even from a biblical standpoint, inasmuch as the promise of universal sovereignty was renewed after the deluge and expressed in even stronger terms than before the fall.

Dugald Stewart admits "a certain latitude of action, which enables the brutes to accommodate themselves in some measure to their accidental situations." In this arrangement he sees a design or purpose of "rendering them, in consequence of this power of accommodation, incomparably more serviceable to our race than they would have been if altogether subjected, like mere matter, to the influence of regular and assignable causes." Of the value of this power of adaptation to the animal itself in the struggle for existence the Scotch philosopher had no conception.

In the great majority of treatises on moral science, especially in such as base their teachings on distinctively Christian tenets, there is seldom any allusion to man's duty toward animals. Dr. Wayland, who has perhaps the most to say on this point, sums up his remarks in a note apologetically appended to the body of his work. He denies them the possession of "any moral faculty," and declares that in all cases "our right is paramount and must extinguish theirs." We are to treat them kindly, feed and shelter them adequately, and "kill them with the least possible pain." To inflict suffering upon them for our amusement is wrong, since it tends to harden men and render them brutal and ferocious in temper.

Dr. Hickok takes a similar view and broadly asserts that "neither animate nor inanimate Nature has any rights," and that man is not bound to it "by any duties for its own sake. . . . In the light of his own worthiness as end, . . . he is not permitted to mar the face of Nature, nor wantonly and uselessly to injure any of her products." Maliciously breaking a crystal, defacing a gem, girdling a tree, crushing a flower, painting flaming advertisements on rocks, and worrying and torturing animals are thus placed in the same category as acts tending to degrade man ethically and æsthetically, rendering him coarse and rude, and making him not only a very disagreeable associate, but also, in the long run, "an unsafe member of civil society." These things are considered right or wrong solely from the standpoint of their influence upon human elevation or degradation. "Nature possesses no product too sacred for man. All Nature is for man, not man for it."

Man is as truly a part and product of Nature as any other animal, and this attempt to set him up on an isolated point outside of it is philosophically false and morally pernicious. It makes

fundamental to ethics a principle which once prevailed universally in politics and still survives in the legal fiction that the king can do no wrong. Louis XIV of France firmly believed himself to be the rightful and absolute owner of the lives and property of his subjects. He held that his rights as monarch were paramount and extinguished theirs, that they possessed nothing too sacred for him, and the leading moralists and statists of his day confirmed him in this extravagant opinion of his royal prerogatives. All the outrages which the mad Czar, Ivan the Terrible, perpetrated on the inhabitants of Novgorod and Moscow, man has felt and for the most part still feels himself justified in inflicting on domestic animals and beasts of venery.

It is only within the last century that legislators have begun to recognize the claims of brutes to just treatment and to enact laws for their protection. Torturing a beast, if punished at all, was treated solely as an offense against property, like breaking a window, barking a tree, or committing any other act known in Scotch law as "malicious mischief." It was regarded, not as a wrong done to the suffering animal, but as an injury done to its owner, which could be made good by the payment of money. Not until a little more than a hundred years ago was such an act changed from a civil into a criminal offense, for which a simple fine was not deemed a sufficient reparation. It was thus placed in the category of crimes which, like arson, burglary, and murder, are wrongs against society, for which no pecuniary restitution or compensation can make adequate atonement.

Even this legislative reform is by no means universal. The criminal code of the German Empire still punishes with a fine of not more than fifty thalers any person "who publicly, or in such wise as to excite scandal, maliciously tortures or barbarously maltreats animals." This sort of cruelty is classified with drawing plans of fortresses, using official stamps and seals, and putting royal or princely coats of arms on signs without permission, making noises, which disturb the public peace, and playing games of hazard on the streets or market places. The man is punished, not because he puts the animal to pain, but because his conduct is offensive to his fellow-men and wounds their sensibilities. The law sets no limit to his cruelty, provided he may practice it in private.

Again, in all enactments regulating the transportation of live stock our legislation is still exceedingly defective. The great majority of people have no conception of the unnecessary and almost incredible suffering inflicted by man upon the lower animals in merely conveying them from one place to another in order to meet the demands of the market. It is well known that German shippers of sheep to England often lose one third of their consignment by suffocation, owing to overcrowding and imperfect ventilation.

Beasts are still made to endure all the horrors to which slavers were once wont to subject their cargoes of human chattels in stifling holds on the notorious "middle passage."

The late Henry Bergh states that the loss on cattle by "shrinkage" in transporting them from the Western to the Eastern portion of the United States is from ten to fifteen per cent. The average shrinkage of an ox is one hundred and twenty pounds, and that of a sheep or hog from fifteen to twenty pounds; and the annual loss in money arising from this cause is estimated at more than forty million dollars. The amount of animal suffering which these statistics imply is fearful to contemplate. Here and there a solitary voice is heard in our legislative halls protesting against the horrors of this traffic, but so powerful is the lobby influence of wealthy corporations that no law can be passed to prevent them. Not a word ever falls from the pulpit in rebuke of such barbarity; meanwhile the railroad magnates pay liberal pew rents out of the profits, and listen with complacency one day in the week to denunciations of Jeroboam's idolatry and the wicked deeds of Ahab and Ahaziah, as recorded in the chronicles of the kings of Israel.

The horse, one of the noblest and most sensitive of domestic animals, is put to all kinds of torture by docking, pricking, clipping, peppering, and the use of bearing reins solely to gratify human vanity. As a reward for severe and faithful toil he is often fed with unwholesome and insufficient fodder on the economical principle announced by the manager of a New York tramway that "horses are cheaper than oats." It is an actual fact, verified by Henry Bergh, that the horses of this large corporation were fed on a mixture of meal, gypsum, and marble dust, until the Society for the Prevention of Cruelty to Animals interfered and finally succeeded in putting a stop to the practice.

The Americans, as a people, are notorious for the recklessness with which they squander the products of Nature, of which their country is so exceedingly prolific. This extravagance extends to all departments of public, social, and domestic life. No land less rich in material resources could have borne for any length of time the wretched mismanagement of its finances to which the United States has been subjected ever since and even before the close of the civil war. There is not a government in Europe that would not have been broken down and rendered bankrupt by the tremendous and wholly unnecessary strain put upon it by crass ignorance of the most elementary principles of finance and demagogical tampering with the public credit. The same wasteful spirit involves also, as we have seen, immense suffering to animals on the part of soulless and unscrupulous corporations, in which intense greed of gain is not mitigated by the influence of individual kind-

ness, and by which horses are treated as mere machines, to be worked to their utmost capacity at the smallest expense, and neat cattle as so much butcher's meat to be brought to market in the quickest and cheapest manner.

Erasmus Darwin, in his Phytologia, or the Philosophy of Agriculture and Gardening (London, 1800), endeavors to vindicate the goodness of God in permitting the destruction of the lower by the higher animals on the ground that "more pleasurable sensation exists in the world, as the organic matter is taken from a state of less irritability and less sensibility and converted into a greater." By this arrangement, he thinks, the supreme sum of possible happiness is secured to sentient beings. Thus it may be disagreeable for the mouse to be caught and converted into the flesh of the cat, for the lamb to be devoured by the wolf, for the toad to be swallowed by the serpent, and for sheep, swine, and kine to be served up as roasts and ragouts for man; but in all such cases, he argues, the pain inflicted is far less than the amount of pleasure ultimately procured. But how is it when a finely organized human being, with infinite capabilities of happiness in its highest forms, is suddenly transmuted into the bodily substance of a boa constrictor or a tiger? No one will seriously assert that the drosera, *Dionæa muscipula*, and other insectivorous and carnivorous plants are organisms superior in sensitiveness to those which they devour, or that this transformation of animal into vegetable structure increases the sum of pleasurable sensation in the world. The doctrine of evolution, which regards these antagonisms as mere episodes in the universal struggle for existence, has forever set aside this sort of theodicy and put an end to all teleological attempts to infer from the nature and operations of creation the moral character of the Creator.

Seeking for a higher meteorological station among the mountains of Peru than that of Mount Chanchani, Prof. Bailey, of the Harvard College Observatory, has established a station upon the top of the volcano El Misti, at an elevation of nineteen thousand two hundred feet. A path has been constructed by which mules have been led to the summit, and beside the meteorological shelter a wooden hut has been built there. A survey of the crater has been made, and a stone hut has been erected on the side of the mountain at a height of fifteen thousand feet. The temperature, pressure, moisture, and velocity and direction of the wind are recorded at the summit station by self-registering instruments. The sheets are changed at intervals, thus giving a record of atmospheric conditions at a height hitherto unattempted. The use of beasts of burden at these heights offers an opportunity in the future of carrying instruments and conducting experiments at altitudes heretofore regarded as inaccessible for these purposes. The mountain, as seen from every direction, is an isolated sharp peak. It is, therefore, especially suited for the study of the upper atmosphere.

THE WORK OF DUST.

By Dr. P. LENARD.

WHEN a beam of sunlight enters a darkened room through a hole in the window shutter, it can be seen along its whole course. The light is reflected to every side, and made to reach the eye by the dust in the air of the room. We do not see the sunbeam itself, but the dust which is illuminated by it; and individual bodies can be perceived on a closer inspection floating in the beam. The dust may be much more plainly observed in still air, as it settles on objects. It is extremely slow in falling to the ground, although it consists of matter which in larger masses falls very speedily. This we can test by collecting dust and compressing it into a ball. In this process of compression a very large part of the exposed surface which the particles presented to the air is caused to disappear; and it was by means of this great extent of surface that the air bore enough upon the particles to support them against falling. The finer the dust the more extended is its surface in proportion to its mass, and the more it is delayed in falling through the air. It may seem useless to speak of the part played by this dust in Nature; for what noticeable effect can this insignificant stuff bring about? We have, however, as can be shown, no right to regard it as a little thing.

Dust has a very large share in nearly all the phenomena of the earth's atmosphere. It is what makes the clear sky appear blue; and when we look up into the sky we see the dust in the atmosphere illuminated by the sun. There is nothing else before us that can permit the light to reach the eye. Light goes invisible, straight through all gases, whatever their chemical composition. The dust catches it, reflects it in every direction, and so causes the whole atmosphere to appear clear, in the same way that it makes the sunbeam visible in the darkened room. Without dust there would be no blue firmament. The sky would be as dark as or darker than we see it in the finest moonless nights. The glowing disk of the sun would stand immediately upon this dark background, and the same sharp contrast would prevail upon the illuminated surface of the earth—blinding light, where the sun's rays fall, and deep black shadows where they do not. Only the light of the moon and the stars, which would remain visible in the daytime, would be able to temper this contrast in a slight degree. The illumination of the earth's surface would be like that we see with the telescope on the lunar landscapes; for the moon has no atmospheric envelope that can hold floating dust. We then owe to dust the even moderately tempered day-

light, adapted now to our eyes; and it is that which contributes much to the beauty of our landscape scenery.

But if dust makes the sky appear clear, why is the color of the sky blue? Why does dust, of the different constituents of white sunlight, reflect the blue rather than the green, yellow, and red? This fact is connected with the size of the dust particles. Only the finest dust settles so slowly that it can be spread everywhere by means of the air currents, and can be found constantly in all strata of the atmosphere; and special importance can be ascribed only to these finest particles. The coarse parts soon fall to the ground. Let us consider the fine mechanism of light, the extremely short ether waves which determine its existence. These waves, although they are of even less than microscopic size, are not all equally long. The shortest are those that give blue light, while all the other colors are produced by longer waves. The fine atmospheric dust contains many particles which are large enough to reflect the short blue ether waves, fewer that can reflect green and yellow, and still fewer large enough to reflect the long red waves. The red light, therefore, goes on almost without hindrance, while the blue is more liable to be diverted, and thus to reach the eye. A similar phenomenon may be observed on a larger scale on water which is roughened with waves of different lengths, and on which pieces of wood are floating. The pieces of wood stand in the same relation to the water waves as the dust particles to the ether waves. The great long waves pass the blocks undisturbed, only rocking up and down; while the finer ripples of the water are turned back, as if the blocks were firm walls.

The finest dust thus appears blue. Look at the smoke that rises from the glowing end of a cigar. It appears on a clear day, especially in the presence of much blue light, of the most beautiful sky blue. But that part of the smoke that is drawn through the cigar, and is seen at the other end, is composed of coarser particles, which are large enough to reflect the longest ether waves, including all the constituents of white light. It therefore appears whitish. The same difference is found between the dust in the country and that in the town. There is much coarse dust in large towns, when the sky over them is often gray, while only the finest blue dust is carried up in the country. The dust is also variously assorted at different heights above the surface of the earth. The coarser dust will be found at the lower levels, where it is produced. On mountains we have most of the dust beneath us, while the rarefied air can sustain only the finest floating particles. Hence the sky on high mountains is clear and deep blue, even almost black, as if it were without dust. Only when we look at the lower strata, toward the horizon, does the color pass into gray.

Why is the sky in Italy and the tropics of a so much deeper blue than that of western Europe? Is the dust there finer? It is really so; not that a finer quality of dust is produced there, but because in the moist climate of the North Sea countries the dust can not float long in the air without being charged with water and made coarser, while in warmer countries water exists in the air as vapor, and does not become condensed as a liquid on the dust. Only when it is carried by the air currents into the higher strata and is cooled there, does it thicken into clouds? With this we come to the most important function of dust in our atmosphere—the part which it has in the function of rain by reason of vapors condensing upon it. It can be affirmed with certainty that all the water which the sun causes to evaporate on the surface of the sea and on the land is condensed again on dust, and that no raindrop falls unless it had a particle of dust as its primary nucleus.

When we speak of "vapor" we always mean water in the gaseous condition, transparent and invisible, like all other gases but cloudy steam, such as is seen escaping from the boiler of a locomotive. The latter, like the clouds and fogs, is liquid water split up into innumerable fine drops. If the walls of a steam-boiler were of glass, we should be able to see clearly through the part of it occupied by steam. Then we have water in the gaseous form. But when the steam escapes from it into much colder air, it is condensed into liquid drops. The process is precisely the same when the vapor which the sun has drawn up in the lower warm strata of the atmosphere is cooled on rising, and forms clouds. It is usually said that the upper atmospheric strata are colder than the lower, because they permit a perfect passage of the solar rays through them, and are therefore not warmed, while the rays, on the other hand, warm the surface of the earth, and that warms the air. This is true, but it does not explain why the upper strata of the air do not become warmed in the course of time. The supposition of a cooling of these strata by space does not afford a sufficient cause, for a body which, like the air, stores up little heat, likewise by a fixed law sends little out. Were the atmosphere perfectly still it would, in fact, be warmed all through from the earth's surface. But it is in constant motion, and the heat is consequently very unevenly distributed through it. When a column of air rises into the heights from the earth's surface, it expands greatly, for the pressure to which it is subjected is much less in the higher regions than below; and whenever a gas expands it becomes colder. A quantity of heat is withdrawn from it corresponding with the force which it spends in expanding in pushing itself into the surrounding region. Ascending air, therefore, becomes cooler, descending air warmer. Thus the fact is ex-

plained that by reason of the continuous motions in the atmosphere the equality of temperature, which would exist if all the strata were equally warmed, never can come to pass.

When the rising columns of air contain a sufficient quantity of vapor, it will at a certain height be condensed into drops and form clouds. We say that the cooling is the cause of the condensation. But it is now maintained and proved by experiment that cooling alone is not adequate to do this, and that condensation takes place only on the surface of some solid or liquid body; not in the free, pure air, but on the surface of the dust particles scattered through it. Every drop of a steam-jet or a cloud is a particle of dust covered with water. The experimental proof of this is easily made. We fill a large flask with dustless air by pressing ordinary air through wadding and conducting it into the flask till all the air originally therein has been replaced with filtered air. The wadding holds back all the dust particles. We then let a jet of steam from a boiler into the dustless air of the flask. It remains invisible. Not a sign of the usual cloudy appearance is perceptible. All that we observe is that the inner walls of the flask begin to trickle; the steam is condensed only on them, for there is no other fixed surface. If, now, some ordinary dusty air is blown into the flask, it at once appears to be filled with a thick, rolling cloud. The cloud is composed of as many drops as dust particles have been admitted. If only a little dust is admitted, all the vapor is precipitated upon it, and so loads it with water in a short time that it sinks in heavy drops to the ground. It is raining in our flask. It will soon become clear, and the vapor will be invisible as before.

Without dust there would be no condensation of water in the air—no fog, no clouds, no rain, no snow, no showers. The only condensing surface would be the surface of the earth itself. Thus the trees and plants, and the walls of houses, would begin to trickle whenever cooling began in the air. In winter all would be covered with a thick, icy crust. All the water which we are accustomed to see falling in rain-pours or in snow would become visible in this way. We should at once feel on going out of doors that our clothes were becoming wet through. Umbrellas would be useless. The air, saturated with vapor, would penetrate the interior of houses and deposit its water on everything in them. In short, it is hard to conceive how different everything would be, if dust did not offer its immeasurable extent of surface everywhere to the air. To this we owe it that the condensation of water is diverted from the surface of the earth to the higher, cooler atmospheric strata.

Since the importance of dust in meteorological phenomena has been recognized, experiments have been made in counting the

particles in the air. Pasteur had already begun an investigation in that direction. He filtered a measured quantity of air through gun cotton, which retained all the particles of dust. This was then dissolved in a mixture of ether and alcohol, and the solution was dried to a sheet of clear and transparent collodion, in which the particles could be observed under the microscope and counted. The chief purpose of this experiment was to secure the yeast germs in the air. A better process for counting dust is based on our experiment with the dustless flask, and, like that, was devised by Mr. John Aitken, in Edinburgh. A measured quantity of the air to be tested—say, about a hundredth part of the contents of the flask—is let into it. The counting is facilitated by this dilution. The air in the flask has been already saturated with moisture, while it has been compressed by forcing in some dustless air. A faucet is suddenly opened, when the air expands, is cooled by the expansion, and the vapor settles on all the dust particles, weights them, and causes them soon to sink to the bottom. The bottom of the flask is made of a bright silver or a glass plate, on which a network of square millimetres is scratched. On this network as many drops of water fall as there were dust particles, and they can be counted with a lens. The number of dust particles in a cubic centimetre of air is—in London, for example, even at the borders of the city, and when the wind is blowing toward it from without—nearly a quarter of a million. About the same number are found in the air of Paris, and half as many at the top of the Eiffel Tower. The air of the Alps is very much purer. On the top of the Rhigi there were about two hundred particles to a cubic centimetre, and a few less after a fall of rain. In the relatively pure air of mountain tops the breath is not condensed into a visible cloud, even in cold weather. As we descend and approach villages whose chimney tops are smoking, the accustomed breath clouds appear again. But a steam jet is visible everywhere, for perfectly dustless air is not found anywhere.

Dust is usually spoken of as something peculiar to the earth. It is, however, present in space. Our solar system has its dust atmosphere, although it is extremely thinly sown. Besides the large blocks of matter, the meteoric stones, meteoric dust is incessantly falling from space upon the earth. Attention was first directed to this fact in 1869, when a meteorite fell at Upsala, and a shower of black dust at the same time. The dust was collected, and exhibited the same composition as the meteorite—carbon and iron. Since then several falls of cosmic dust of identical composition have been observed where no meteorites were seen. The recent advance of celestial photography has furnished images of externally faint clouds floating in space. These clouds do not

participate, like earthly things, in the revolution around the axis, but remain fixed among the stars through the night. When near enough to the earth they can be seen with the naked eye as luminous clouds, long after sunset, till they are covered by the earth's shadow.

The presence of dust in planetary space is not strange. In the midst of it is the sun, the surface of which is like an immense volcano. We can only ask how the dust clouds of the solar eruptions can be diffused in space, against the attraction of the sun. An answer to this question is afforded by the electro-magnetic theory of light, and we can rely upon it because the theory has been confirmed by experimental demonstration. It teaches that the lighter undulations of the ether are of an electrical nature, and that consequently light exerts a pressure on all bodies upon which it falls. The illuminated body is repelled from the source of the light. We have also learned the amount of this pressure. It is so small that the scale of the most sensitive balance is not moved by it when the clear sunshine falls upon it from above; but it increases with the extent of the surface exposed to the light. Let us now suppose a body isolated anywhere in planetary space. It is subject to general attraction and is drawn toward the sun. The force with which the light of the sun repels it is slight as compared with the attraction. Let us imagine this body divided into smaller and smaller fragments. It then offers the sun a larger and larger surface, and in the same measure the force increases with which all the parts collectively are repelled from the sun. The amount of attractive force is, on the other hand, not changed, for it depends upon the mass of the body, and that has not been altered. It will be seen that the division of the body has only to be carried far enough for the repulsive force ultimately to exceed the attraction. Calculation shows that this is already the case when the body is changed into a dust cloud of not excessive fineness. Such a dust cloud will be no longer attracted toward the sun, but will be driven away by its light. It will be like the comets' tails, which consist chiefly of dust, radiate from the nuclei, and are always turned away from the sun.

Thus, even insignificant, common dust has its considerable part in the processes of Nature; and there is as much of the wonderful and mysterious concealed in it as in anything else.—*Translated for The Popular Science Monthly from Die Gartenlaube.*

In the interest of good roads, the watering carts of Malden, Mass., are furnished with broad tires, of which the forward pair are set nearer together than those of the rear, so that the track of the former is just inside of that of the latter. The carts thus serve as rollers as well as for their primary purpose.

ARCTIC TEMPERATURES AND EXPLORATION.

By STUART JENKINS.

AT the recent annual meeting of the Association of Ontario Land Surveyors, held in the city of Toronto, the statement was made that, if the Canadian Government determined to run a meridian to the north pole, Canadian surveyors would carry the work through. As a proof of the faith that is in them, they have appointed a committee to consider and report upon the matter.

The assertion is not as wild as it may seem, and I think it will prove interesting to the public to show what Canadian surveyors have already done, and compare their methods and experience with those of arctic explorers.

The extreme cold of the arctic regions is generally looked upon as the principal bar to exploration in that direction, notwithstanding the fact that men have endured its rigors for years without injury. Take some of the cases on record. In 1743 four seamen went ashore on the island of Spitzbergen from a Russian vessel. A heavy storm drove the ship away before they could rejoin her, and they were left with nothing but a gun and enough ammunition to kill twelve deer. That was their entire outfit, yet they managed to live and keep their health for six years, when three of them were rescued, the fourth having died. No properly organized polar expedition would have to submit to the hardships which they must have endured.

In 1819–'20 Parry wintered on Melville Island in latitude 74° 26′. The greatest cold was experienced in February, when the thermometer fell to −55° F., and for fifteen hours was not above −54° F. The expedition was absent eighteen months, and out of two ships' crews only one man died—of a disease in no way referable to the hardships of the voyage.

Between 1853 and 1855 Dr. Kane passed two winters in Smith's Sound in latitude 78½°, and he records the mean temperature of the three summer months as +33° F., and of the nine winter months as −16·8° F. As to the possibility of traveling under the conditions existing in these high latitudes, it may be considered as established by the experience of McClintock, who in 1851 reached one of the western points of Melville Island, distant from his winter quarters three hundred and sixty miles in a direct line, a journey which required eighty days going and returning for its accomplishment. Among the things said to have been experienced by arctic explorers three may be mentioned: 1. That men issuing suddenly from their shelter into a temperature of −60° F. fell senseless. 2. That a man rushing out bare-handed

to extinguish a fire, when the thermometer stood a little below $-50°$ F., had his fingers immediately frozen, and as it was found impossible to restore the circulation they were amputated. 3. That when it was extremely cold it was almost impossible to make the wood burn. I will come to these later.

Now for the experience of a Canadian surveyor. It was my privilege to be connected as instrument-man with a survey party which went out to the Canadian Northwest under the command of Mr. G. B. Abrey, D. L. S. (now engineer of Toronto Junction). The party consisted of fourteen men all told, and was out under canvas for twelve months, from June, 1882, to June, 1883. We were running standard parallels, and moved camp every day. This necessitated the employment of fourteen horses, two buckboards, and twelve carts, the wheeled vehicles being replaced in winter by the same number of toboggans. Winter commenced on the 1st of November, when snow fell to the depth of two feet and remained. We then left the plains south of Battleford and made our way to Fort Pitt, near which our winter work started. Our outfit consisted of four ten-ounce duck tents, in three of which were small sheet-iron box stoves, and in the fourth, the cook's tent, a sheet-iron cook stove. Our winter food was composed of pork, beans, dried apples, and bread, with tea and sugar; to which may be added eight hundred pounds of fresh beef, and the flesh of one elk or wapiti and one jumping deer. When we could we shot prairie chickens, but this was not very often.

For clothing I wore woolen underclothing, such as I now wear in the city of Toronto, a flannel shirt, and over these caribou breeches with long woolen stockings drawn over them, a chamois-leather vest, and a small single-breasted tweed coat such as is worn in the city before overcoats become necessary in the fall. My feet were clothed with duffle and moccasins, and my head with a double, knitted, Hudson Bay tuque, which can be pulled right down over the ears. A pair of common woolen mits completed my outfit. At no time during the winter did I wear either overcoat or muffler. Indeed, neither the one nor the other was to be found in the camp. Mr. Abrey's dress was nearly the counterpart of mine, and the men wore woolen clothing altogether.

At night Mr. Abrey and I used two pairs of Hudson Bay blankets and two buffalo skins each. The blankets we sewed up into bags, and put one buffalo skin beneath and one over us. We slept on folding stretchers, which was, of course, not as warm as sleeping on the ground. Mr. Abrey, being slightly bald, wore a woolen nightcap, but I never covered my head the winter through. The men's sleeping outfits consisted of blankets only.

Our firewood was dry poplar sticks from one to two inches through. This makes a good hot fire, and *the colder the day the*

better it burns—that is our experience. But by no means can you make a fire of it burn more than half an hour without replenishing. In consequence of this, no attempt was made to keep fires burning at night. An hour after we were in bed the temperature inside the tent was the same as that outside. At no time was the temperature inside the tent raised high enough to thaw out the ground, which would only have given rise to wet feet without adding to our comfort.

A regular record of temperature was kept during the winter. Our thermometer was a standard spirit one graduated to $-62°$ F., and had been tested at the Toronto Observatory. The record is on file in the Dominion Crown Lands Office. From the 1st of November the temperature fell in a series of remarkably regular jumps—that is, there would be three days of cold, then a few days of slightly higher temperature, then another three days of cold, and so on, each drop being colder than the last. This went on with unbroken regularity until the third week in January, when it began to rise again in the same way and with equal steadiness.

On Christmas day the weather was beautiful, still and cloudless, and the thermometer stood just at zero. I spent the day in making a pair of snowshoe frames, out of white birch, which was plentiful round the camp, my tools being an axe and an Indian crooked knife, which is nothing but a one-handed draw knife, shaped much like a farrier's knife. I worked all day with the door of the tent wide open, in my shirt sleeves, and barehanded; and from 9 A. M. to 3 P. M. there was no fire in the stove. I slipped on my coat at noon when I was eating my dinner, but took it off again immediately after. The men spent most of the day lounging about the camp in their shirt sleeves, smoking and skylarking.

The second week in January we received word that Mrs. Abrey was in Battleford waiting to join us in camp. She had come from Toronto and had traveled across the open country in the mail sleigh from Qu'appelle to Battleford *via* Duck Lake and Carleton. Mr. Abrey immediately left with two horses and carioles (i. e., toboggans with raised sides of rawhide), and one halfbreed. He carried no tent. The distance to Battleford from our camp was over a hundred miles, through an open country, with here and there clumps of small poplar and birch.

I went on with the line, and the third day after Mr. Abrey left us reached the shore of Frog Lake, a few years later the scene of a horrible massacre. The next morning the cook came bustling in with the breakfast, his shirt sleeves as usual rolled up above his elbows.

"The bottom's dropped out of the thermometer," he said with a laugh.

I hurried outside, and, sure enough, the spirit had deserted the tube, and lay inclosed in the bulb—that is, it was lower than −62° F. It was startling, but there was no getting round the fact. The news spread through the camp, and the men came crowding round to see the unusual phenomenon. One man ventured the opinion that we had got to the north pole by mistake, but they looked upon it more as a joke than anything else, and were perfectly satisfied, because it meant a holiday. Mr. Abrey had made the rule that when the thermometer went below −30° F., we would not go on the line. We afterward came to the conclusion that there was nothing to prevent our working at much lower temperatures, but the rule once established it was impossible to alter it without creating discontent among the men. I went out that day two miles from camp on snowshoes, just to see how it would go, and, although it was cold at starting, I was warm enough before I got back.

The next night the thermometer went down to −58° F., and the third night to −61° F. Now, according to all precedent, we should have spent those three nights cowering with quaking hearts over the stoves, and using up the cook's fat to make the fires burn. As a matter of fact we went to bed as usual and slept without any fires at all. Not only that, but we suffered no discomfort. The only unpleasant thing about it was turning out of one's blankets in the morning to light the fire, and that I admit *was* cold, but still nothing that a strong man could not stand with equanimity.

But what will be thought when I state that during those three days of extreme cold Mr. and Mrs. Abrey were on their way from Battleford to Fort Pitt, *and slept out without any tent, and without keeping up a fire through the night?* If a Canadian surveyor's wife could do this, a Canadian surveyor can get to the north pole.

The next cold snap after this the thermometer reached −58° F., but it did not touch −60° again that winter. Not once during the winter did any of the party suffer from frostbite. I have repeatedly seen the men chopping bare-handed with the thermometer at −25° F.; and have myself taken observations of the North Star when it was −35° F. It was cold undoubtedly, but it was not as bad as taking the same observation in the mosquito season.

During the whole twelve months we were out we had not a day's sickness among us, but everybody was decidedly fattest and heartiest during the coldest weather. One fallacy we completely exploded—i. e., that extreme cold produces drowsiness. We never saw any indication of it, and since then I have traveled some thousands of miles across the ice of the Georgian Bay in temperatures varying from +32° to −30° F., and never experienced the slightest inclination to drowsiness. Only once in my life

have I felt it, and that was in the middle of summer, when as a very young man I was fool enough to try and walk fifty miles in a day without any previous training. During the last mile or two my companions had hard work to keep me on my feet, and at the end of the journey I subsided into a chair and went fast asleep, and in that condition was carried to bed, where I slept for twenty-four hours. I was simply "played out," and it is *that*—not cold—which produces the drowsiness so often referred to. More than once since then I have walked fifty miles on snowshoes and never felt anything of the kind, but I made it a rule to stop every four hours and brew some tea and eat a good square meal. When this practice is followed, it is astonishing how far a man can go without excessive fatigue. The "fatal drowsiness," as it is so often called (which is surely a near relation of "that tired feeling"), is nothing but Nature's final rebellion against a reckless overtaxing of the muscular power without renewing the waste, which of course goes on most quickly in cold weather.

A more recent example of the staying powers of Canadian surveyors is furnished by the exploration of the "Barren Lands" and Chesterfield Inlet just brought to a successful completion by the Tyrrell brothers for the Dominion Geological Survey. The party consisted of the two Tyrrells and six Indian canoemen, a model party for exploring purposes. The total distance covered by them in canoes from Athabasca Landing to Fort Churchill on Hudson Bay was two thousand two hundred miles, and thence to Winnipeg on foot or by dog train one thousand miles. Of the two thousand two hundred miles, eight hundred and fifty was through an entirely new country never before traveled by white men, and five hundred miles was over the open sea of Hudson Bay at the very worst season of the year, between the middle of September and the middle of October. It was during this trip down Hudson Bay that they endured the greatest hardships. They ran out of provisions, there was no wood along the coast, and on one occasion they were unable to land for forty-eight hours on account of the heavy sea. None but Canadians would ever have ventured on such a trip in canoes; none but Indians could have carried it through successfully. All the stirring incidents of this daring journey have been fully published by the press throughout the continent, and need not be recapitulated here. They prove conclusively that the boast of the Ontario Land Surveyors is based on recorded facts, of which any nation might be proud.

In considering the record of past failures in the arctic regions —for, in spite of the magnificent heroism displayed, they were nothing but failures—two points stand out clear and distinct, viz., that the pole will never be reached in ships, and that it can

never be reached by any such parties as have hitherto been sent out. The men who so freely risked their lives were not to the manner born, and what they were called upon to endure was so violently opposed to all their ordinary experience that they were heavily handicapped at the very start. With the uneducated seamen the resulting mental depression must have been a most difficult thing to combat, thus creating a double tax on the already strained nervous courage of their more highly educated leaders. British seamen are fine fellows and possess in a high degree the courage of their race, but nothing would induce a Canadian surveyor to lead a gang of them into the arctic regions, or even take them out on an ordinary bush survey. They would simply be useless. What are wanted are trained *voyageurs* who are equally at home in canoes or on snowshoes; and not too many of them. With the exception of Dr. Kane's (by far the most successful), arctic exploring parties have been too unwieldy. The one hundred and five ill-fated souls who abandoned the Erebus and Terror starved to death where a party like the Tyrrells' would probably have won their way back to civilization. Had Kane been backed up as he should have been, he would most likely have reached the pole, and when that point is attained, as it certainly will be, it will be over the course followed by him, and by means of dog trains and canoes or boats.

In spite of probable criticism, I am going to sketch a plan for reaching the north pole, drawing on my own experience and that of Canadian surveyors and explorers. I assume at starting that expense is simply no consideration whatever. If a feasible scheme is put forward, I believe that there is enough enterprise, private and governmental, among Anglo-Saxons to carry it through, even if it cost a million.

The exploring party would be carried by steamer to the head of summer navigation on Baffin Bay, where a depot would be established as a base of operations. Here provisions, houses, steam launches, sailboats, canoes, dogs and sleighs, fuel, and all the other accessories, with the exploring party, would be landed, and the steamer could return to winter at Upernavik or Disco. The former place is only one thousand miles from the pole, the distance covered on foot by the Tyrrells, in the middle of winter, with the thermometer often at $-40°$ F., and without tents. A point to be considered is, whether it would not be well to have a second steamer built on the principle of the St. Ignace, the steam ferry at the strait of Mackinac. This boat made an extraordinary record on her trial trip, shearing through ice three feet thick with the greatest ease. With such a vessel, it might be possible to push a long way up Smith's Sound. That point could be determined by a preliminary survey of the head of Baffin Bay.

The main exploring party should be composed of fifteen men—five white men and ten Indians. The white men would be made up of three Canadian surveyors, for the scientific purposes of the expedition; one doctor, as a concession to popular prejudice; and one journalist or reporter to work with pencil and camera. As a journalist myself, I claim the right of the fourth estate to be represented. The Indians should be picked *voyageurs* from the Georgian Bay. These men are good canoemen, first-class sailors, are used to ice traveling, and have walked on snowshoes since they could walk at all. Above all, they are faithful workers and reliable men.

The main depot or base would probably be situated at the mouth of Smith's Sound, in latitude 78°. That point has been reached more than once, and can be again. But it is not necessary or expedient to push it farther than the ordinary head of summer navigation, because it would become a permanent meteorological station, and would ultimately be connected with Newfoundland by cable, a distance of sixteen hundred and eighty geographical miles. The buildings would be ordinary American frame buildings, framed on two-by-six scantling, and sheeted with four layers of matched boards, two outside and two in, with heavy felt paper between the sheeting. With double windows and double doors, such a building properly heated will defy the cold of space. The heating would be accomplished with hard coal and base-burners. The buildings of course would be taken up all ready to put together, and, with the labor available from the ship, ought to be ready for occupation in a fortnight. This base would have a resident staff of officials, mechanics, and *voyageurs*, whose duty it would be to take care of the supplies, and back up the main exploring party by pushing forward provisions and other necessaries as they advanced farther north. Subsidiary depots should be established every hundred miles until the pole or an open polar sea is reached. These minor depots would be nothing but tents of stout duck, of the Northwest tepee pattern, raised on light but strong poles of cedar, and spiked to the ice with iron or copper spikes. They would contain provisions, blankets, stoves, and fuel, and, as long as the main party was out, would be connected with the head depot by regular dog service. Three or even four of these would probably be located the first fall.

About the middle of the following April (Kane abandoned his ship on the 20th of May) the real work of the expedition would commence. The problem presented to the surveyors would be to overcome the seven hundred and twenty miles separating the main depot from the pole. At the lowest estimate there would be five months in which to do this, necessitating an average daily

advance of nine miles on the straight line, to take them there and back. As an actual fact they could travel for six or seven months if necessary, and the going would probably be better in winter than in summer, for snow is the traveler's friend in high latitudes.

The main party, with an interpreter for communicating with the Eskimos, would start out with sixteen dog teams carrying tents, stoves, fuel, blankets, etc., and two big Peterboro canoes. The fuel would have to be specially constructed. Coal is unsuitable and wood is too bulky. I know from personal experience that an ordinary porous brick soaked in coal oil for twenty-four hours will burn for over two hours, and makes a first-class torch for spearing fish by; and I do not see why compressed bricks made of sawdust soaked in coal oil would not make a capital fuel. In a properly constructed sheet-iron stove it would throw an intense heat and could be lighted in an instant. In summer time, of course, very little fire would be needed except for cooking, but after the thermometer got below zero fires would be necessary night and morning. The best fuel for the purpose could easily be determined by experiment, but whatever its character it must be compact in form and must yield the greatest possible combustion for its bulk. All provisions should be packed in sealed tin cases of a convenient size and weight for handling. They would then suffer no injury from rain. The tents should be conical in shape, eleven feet in diameter at the bottom, and stretched on ten light cedar poles hinged to a ring at the top, and shod with iron at the bottom. This is the most convenient tent made. It can be set or struck in less than a minute, because it opens and shuts like an umbrella. It gives the greatest floor room for the amount of canvas. There is no large space overhead to absorb the heat. And it offers the least resistance to the wind, and if properly spiked can not blow down—a valuable property when the thermometer is away below zero. Four such tents would accommodate the exploring party. The character and quantity of food would be easily determined by the surveyors, but one article would have to be sternly eliminated, and that is alcohol. My allowance for sixteen men for five months would be two bottles of brandy, and I think they would come back unopened. The traveler's standby in cold weather is tea, and men will do more hard work on it than they ever could accomplish on any form of spirit. Of course, there are many minor details which need not be enumerated here.

What difficulties the party would have to contend with above the eighty-second parallel, of course, can not be known. Their motto at starting would be, "Get there somehow," and there is no doubt they would live up to it. If the theory of a Polynia or

open polar sea is correct, they would take to the canoes and follow along the west coast of Greenland as far as it may project northward. The Tyrrells made five hundred miles over the waters of Hudson Bay in this way, and others can do the same. In all they did, however, the surveyors would be guided by past practical experience. If they had their choice they would probably prefer ice to water, but whatever came they would meet it with the equanimity of brave and resourceful men. Above all others, their training in the field has qualified them to cope with the difficulties they are likely to encounter.

It is quite probable that the pole would not be reached the first summer. From Mount Parry to the pole is five hundred and fifty miles. If the most northerly point of Greenland does not reach within a hundred miles of the pole and there were no islands visible beyond, they would scarcely trust themselves on a trackless sea in canoes. They would then have to return and commence the arduous task of portaging a good-sized steam launch piecemeal from the head depot to the polar sea. The whole freighting force of the expedition would be laid under contribution, and the work pushed with unflagging vigor. The boat, of course, would be specially constructed beforehand for the purpose, and would go together and be ready for navigation in a week. Allowing the launch a speed of six miles an hour, the pole would be reached in four days.

The way to accomplish a task of this kind is to go at it quietly and systematically, and stay right there until it is done. Ship companies have always been confronted with the terrifying possibility of being cut off from all human succor. My plan renders such a contingency impossible. The steamer would visit the main depot every summer and then sail for Newfoundland, whence news of the expedition would be telegraphed over the world. The members of the expedition could thus communicate with their friends, and the depressing feeling of isolation would be obviated. There would be no danger of running out of supplies, and the expedition could go cheerfully ahead with the assurance that their retreat was provided for.

There are many reasons why Baffin Bay and Smith's Sound should be chosen as the route to the north pole. To put them shortly: 1. Greenland is the most northerly land known, and probably extends a good deal farther than at present explored. 2. Smith's Sound has been already traversed as far as the open sea. 3. Upernavik is the most northerly permanent abode of civilized man. The moral influence of this on the expedition would be great, because it would be but a short distance from the main depot. 4. A whisp of the Gulf Stream runs along the west coast of Greenland as far as the seventy-eighth degree of latitude, rais-

ing the average temperature 9° F. above that of the east coast, and rendering summer navigation certain. 5. According to Réclus, the January isothermal of Frog Lake, where I wintered in 1883, twists northward until it runs through upper Greenland, so that, although the winter might be longer, it would not be more rigorous. The same authority concludes, from various ascertained facts, that within the Arctic Circle the summer mean increases as you get nearer the pole, and favors the theory of an open polar sea. It is certain that the pole of greatest cold lies southwest from Greenland among the western islands of the polar archipelago. Lastly, Disco possesses coal, the most important item in steam navigation.

From a consideration of the foregoing points the situation resolves itself into a simple question of money. If the funds are provided, the men are here who are both willing and qualified to carry the work through, and this article has been written as an appeal to both governments and individuals to come forward and once for all settle the scientific questions involved in the location of the north pole. Canada will bear her share undoubtedly, and, what is more to the purpose, will find the men. One difficulty which will beset the organizers of the expedition will be the necessity of dealing with the hundreds of volunteers who, for sentimental reasons, will move heaven and earth to get themselves joined to it. Most of these men will possess absolutely no qualification for the work, and would prove nothing but so much useless lumber. They must all be met with the same unbending negation. Finding the north pole will be no summer picnic. The men to accomplish it must be experienced middle-aged men, whose muscles have been indurated and their minds fortified by a constant acquaintance with cold, hardship, and danger, and nowhere except among Canadian surveyors can you find men who combine these qualities with the necessary scientific attainments. Science knows no nationality, and in a matter of this kind there should be no international jealousy. Let Anglo-Saxons find the money, and those Anglo-Saxons best fitted for the work will undertake it and carry it through.

There is but one more point to be noted. The next five years will be particularly favorable for arctic exploration. We are now approaching a minimum sun-spot period, which experience proves is coincident with a period of mild winters. The last minimum was in 1888, a year of extreme heat and drought followed by a winter of unusual mildness. Going back eleven years, the winter of 1877–'78 was so mild that wild geese remained on the Georgian Bay throughout the winter, and the Collingwood steamers were plying the first week in April—a month earlier than usual. The winter of 1882–'83, which I spent with Mr.

Abrey in the Northwest, was exceptionally severe and occurred during a maximum period. In our daily observation of the sun we watched the spots during the previous summer, and were astonished at their size and number.*

I can only add that when the expedition starts I hope to be one of the party. If it is organized on the lines I have laid down I should set out with an absolute assurance of getting there, and, what is of still greater importance, with an equal certainty of getting back again.

THE NEW MINERALOGY.

By G. PERRY GRIMSLEY.

MINERALOGY, as the *observation* of minerals, is of very ancient date, but such observation was very crude, for the old scholars grouped under one name a great variety of forms, some rocks and some minerals. The earliest writer was a Greek by the name of Theophrastus, who lived about three hundred years before the Christian era. A few centuries later the great naturalist Pliny recorded a number of personal observations. Then followed a blank period extending into the eleventh century, when Avicenna made his mineral classification. In this, the first classification, all minerals were divided into four groups—stones (= silicates), salts, inflammable bodies, and earths. In the next six centuries the only improvement was the substitution of term metals for earths. Through all these many years, it was the beautiful in form, luster, and color of the gems which attracted the attention of men both learned and ignorant. The question of origin was not considered; indeed, it was sacrilegious to think of such a problem, since these were objects of creation, whose genesis, like that of the gods, was not to be revealed to man. It was the work of many centuries to dispel these clouds of ignorance and superstition which blinded and hindered the advance of this study. The only light which did appear was that of the alche-

* From a consideration of Schwabe's sun-spot table I am inclined to believe that Parry's three voyages, extending from 1819 to 1825, were undertaken during a minimum period. Schwabe's table, of course, only commences in 1826, but it is certain that the minimum period must have fallen within the above years. On the first voyage Parry sailed completely through Lancaster Sound, which he found a wide and noble channel, clear of ice, and the color of the sea, and there is little doubt that had he possessed a fast steamer he would have made the Northwest passage instead of being forced to winter on Melville Island. Dr. Kane, on the contrary, was out at the close of a maximum period of exceptional length and severity, and he experienced the lowest mean temperature on record. It was during this very same period that the ill-fated Franklin and all with him were lost, the Erebus and Terror being abandoned after nineteen months' imprisonment in the ice.

mists, those wizards who vainly searched for the lucky stone which would transform all into gold. From the ashes of their fires comes as a heritage the application of heat and fusion to aid in investigation, but even the value of these was not clearly seen for several centuries thereafter.

Behind the clouds there was a light, and the time at last came for it to melt these away, revealing a vast new field for thought and study in the inorganic world. Men began to look more carefully at the objects near them, to observe the ways of Nature, and to attempt the solution of some of her mysteries; then it was seen that even in the inert stone there was a story to be read—an ever-changing story full of historical interest, if only one could read it.

It is interesting to note through these centuries the struggles for existence and advancement which finally brought forth, at the beginning of our era, mineralogy as a *science*. In the sixteenth century the work of Agricola laid the foundation for physical mineralogy. In the eighteenth century Cronstedt pointed out the distinction, so long unknown, between rocks and minerals, based on chemical properties. At the beginning of the nineteenth century came the work of Werner and Hauye. These men perfected the methods and made more accurate descriptions of minerals, thus becoming the founders of modern mineralogy, and making their respective countries, Germany and France, the centers for this study. During the present century the growth has been as rapid as it was slow during all the preceding centuries, so that at the present time its students nearly outnumber the species.

The study of the properties of minerals—physical, chemical, and optical—was carefully made and verified over and over again, but the question of origin was unsettled; in many cases it was even impossible to conjecture. So its devotees sought a means of revealing and proving this problem of origin, and then arose what we may term the *new mineralogy*. Germany and France have equal share in the honor of founding the science of mineralogy, but to France belongs the credit of original active investigation into the origin of minerals. This feature of new sciences is becoming quite prominent, and one would infer that there was a very great awakening in the scientific world, for we hear of the new astronomy, the new chemistry, and the new geology; but it is not so much new science, as old science studied by new methods brought about by the great underlying law of the universe, progression, which causes the new of to-day to become the old of to-morrow. The new mineralogy endeavors to solve the problem of origin by the reproduction, artificially, of the mineral using similar agents and like conditions, as in Nature. While attempts were made to reproduce minerals early in the century and even

near the end of the preceding one, the important work has been done since the year 1850, which date may be taken as the beginning of synthetic mineralogy. Through the eighteenth century came many suggestions on the artificial formation of minerals, followed by the crude attempts at the reproduction of petrifactions and incrustations. Unsuccessful attempts finally led to the successful reproduction of marble by James Hall in 1801, the first mineralogical synthesis and the beginning of experimental geology.

The first workers, as would be expected, were chemists; among whom Daubrée stands pre-eminent. When the mineralogists joined in the work, it was found that the conditions governing the chemist's experiments differed from those they could apply. It was early discovered that the forces at work in the formation of minerals escaped the observation of the mineralogists, and, though observed, were considered outside the domain of chemistry. The chemist's aim was to form a mineral *like* the one found in Nature; but the mineralogist, in addition, must use analogous processes to those in Nature. In the chemical sense if the artificial product had the correct chemical composition, reaction, physical properties, such as density, boiling point, and the like, the synthesis was complete. On the other hand, in the mineralogical sense there must be also an entire agreement of the resulting product with the natural one morphologically. It must have the crystal form and also the characteristic type as in Nature, with the same optical properties, in order to be perfect. Thus the chemist could deposit copper by electrolysis, like the copper found in Nature; but this does not show the origin of copper in Nature. His task is the easier one, for he uses his reagents at pleasure, aiming only at the final product. In the course of time, the chemist and mineralogist seeing their mutual needs, united their efforts, and it is on this union that mineral synthesis as a science rests.

The cause of the long delay in the progress of this line of study was the idea, so firmly fixed in the minds of the old chemists, that Nature worked by mysterious means and had at her disposal indefinite time and enormous masses with supposed forces out of all proportion to those used in the laboratory. Then how was it possible in a crucible with a certain number of grammes of matter to reproduce a crystal of the same kind and association as those which the volcano ejected—a crucible a million times larger and under enormous pressure and temperature? The answer seemed too clear to even admit of such a vain attempt; they could not see the *law of proportion* which existed there, but it only needed progressive men to discover it. Even when this law was discovered, the crude means and limited experience at hand

retarded them and made the progress very slow down to the middle of the present century.

At the beginning of the cycle there existed the two opposing geological camps, the one attributing everything to fire, the other all to water; after long years of wrangling their union was accomplished through the efforts of Lyell and his followers. In addition to this, the accumulating observations overthrew two old ideas—namely, that a mineral can only originate in one way characteristic to it, and a single homogeneous magma can give rise to only one mineral. It was found that a mineral may originate under different conditions which are determinable, and that the homogeneous magma may at the same time give rise to different minerals. The various mineralogists appeared to take pleasure in throwing an envelope of mystery around the origin of minerals, and they were regarded, even by Zirkel, as the work of a kind of vital force.

Practical difficulties deterred the progress of the study; the crystals formed were sometimes imperfect and usually microscopic. So it was almost impossible to study them before the development of mineralogical micrography and the advent of the mineralogical microscope. Then it was found that these minute imperfect crystals were of more value and led to greater results than the more beautiful cabinet specimens, for they settled the problems of origin. Natural crystals were found to contain small inclusions which are indices to the origin. If these are vitreous, then the origin is vitreous, and the action of volatile agents is wholly excluded; if these be aqueous, the intervention of water is indisputable. In certain minerals—as quartz, beryl, topaz—liquid carbonic acid appears as an inclusion, giving evidence of their formation under great pressures.

From this brief survey we see the strong prejudices of the ancients are disappearing; observation and the processes of investigation have acquired a remarkable precision; materials and apparatus in the laboratories have been perfected to a remarkable degree.

Under the head of artificial minerals we exclude those accidentally formed in the industrial works, as graphite on the walls of iron furnaces, for such do not answer the question of their origin, since the reagents and conditions remain unknown. Nevertheless, the recorded observations of such products have aided reproduction in the laboratory, and it is of interest that these observations have been noted especially by German workers, while the home of active laboratory investigation is in France. The Germans collected the facts, while the French co-ordinated them, forming hypotheses and then experimenting to prove them. The Russians followed with almost equal success; also much important work has been done in the laboratory by the Germans.

The practical side of a subject must always be considered, the question of utility being a very important one. What claim has this subject for attention and what has it accomplished? It has thrown light on the mode of the natural formation of minerals and rocks. Thus even down to late time water was thought to play an important part in the formation of a great number of volcanic rocks and to be indispensable in the formation of the great group of rocks termed *basalt*. Yet basalt and all the modern volcanic rocks have been formed by purely igneous fusion. Again, certain minerals—as chiastolite, garnet, staurolite, and a large number of metamorphic minerals—are always found impure in Nature, and their exact composition was unknown until reproduced artificially. The majority of natural minerals are complex combinations in which many bodies are introduced by isomorphous agency. Synthesis has furnished the theoretical types and given forms which could be accurately measured and show the true physical properties.

Mineral synthesis determines the individuals belonging to a family and distinguishes the true isomorphism of the series in question. The artificial reproduction of the feldspar series proved that the two members, *albite* and *anorthite*, were isomorphous and could be united in all proportions, some new forms being found which were unknown in Nature. Other mineral types which are suggested by, but are absent in Nature have been formed artificially, thus completing a mineral series, making the limits of isomorphism more clear. This was accomplished by Ebelmen in the spinel family, showing the relation of ferrites, chromates, and aluminates to each other; also by Foque and Levy in the feldspar family, who formed new feldspars with bases of lithia, barytes, strontium, and lead. This work has also been of great assistance to geology, a science which has been encumbered by theories and hypotheses, where observation was in very many cases insufficient to settle definitely the doubts. Synthesis, when applied, enlarged the field of observation and so often furnished definite solutions. Thus the origin of granite was one of the great problems confronting geologists. The opinion that it was purely igneous prevailed in the science for the first part of our cycle, replacing the Neptunist or aqueous theory of Werner, but the difficulties were increased a little later when, by means of the microscope, it was found the quartz was consolidated after the other minerals; this was against the idea of a purely igneous fusion of the granite. The upholders of this theory then argued for an extra fusion of the quartz analogous to sulphur. Élie de Beaumont in 1849 modified the theory by admitting the intervention of water. For proof he called attention to the number and frequency of the minerals sublimed on the pe-

riphery of the massive granites. He thought the water occurred in the form of inclusions in the granite constituents, which was proved ten years later by Sorby. From this time on there was the new theory for a mixed origin of granite. When synthesis was applied it was found impossible to obtain granite by purely igneous fusion.

The new mineralogy has accomplished much and has extended our knowledge of rocks and minerals far beyond even the dream of its founders, so that to-day nearly all known rocks have been formed artificially with the same minerals and under the same associations as in Nature. Of the different mineral species but very few remain which have not been reproduced in the laboratory, and each year decreases this number. The only ones which have not been reproduced are *epidote, allanite, zoisite, staurolite, disthene, andalusite,* and *tourmaline,* a very small number, which will probably be removed in the next few years. All this work has been accomplished in a comparatively short period of time in three countries, France, Russia, and Germany.

Thus we see the new mineralogy has given breadth to the old and has established a better foundation on which to build, since it has disclosed the long-hidden mystery of the origin of minerals and rocks.

SCIENCE AS A MEANS OF HUMAN CULTURE.*

By FLOYD DAVIS, E. M., Ph. D.,
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THE day has long since passed when men expected to meet with success without faithful effort. We now realize that one of the fundamental principles underlying success in any field is concentration of thought and energy in rightly directed channels. We are glad to see so many of our higher institutions of learning, particularly the technical schools through their laboratory methods of instruction, training young men to concentrate their energies. The beneficent results of such training will be enjoyed by generations to come.

The trained intellect grasps in a comprehensive manner details which the untrained can never see; it analyzes subjects in all their bearings and gives wise direction to the advancement of truth. In all scientific work, and even in the business world, the demands are for men trained to comprehend subjects down to the very details in a single glance. A business firm once employed a

* An address delivered at the formal opening of the New Mexico School of Mines, at Socorro, September 5, 1893.

trained young man whose energy and grasp of affairs soon led the management to promote him over a faithful and trusted employee. The old clerk felt deeply hurt that the young man should be promoted over him, and took occasion to complain of it to the manager. Feeling that this was a case that could not be argued, the manager asked the old clerk what was making all the noise in front of their building. He went forward and returned with the answer that it was a lot of wagons going by. He then asked the clerk what they were loaded with, and again he went out and returned, reporting that they were loaded with wheat. The manager again sent him to ascertain how many there were, and he returned with the answer that there were sixteen. Finally he was sent to see where they were from, and he returned, saying that they were from the city of Lucena. The manager then asked the old clerk to be seated, and sent for the young man, and said to him, "Will you see what is the meaning of that rumbling noise in front?" The young man replied: "It is unnecessary, for I have already ascertained that it is caused by sixteen wagons loaded with wheat. Twenty more will pass to-morrow. They belong to Romero & Co., of Lucena, and are on their way to Marchesa, where wheat is bringing one dollar and twenty-five cents per bushel, while it costs only one dollar at Lucena. The wagons carry one hundred bushels each and get fifteen cents per bushel for hauling." The young man was then dismissed, and the manager turning to the old clerk said, "My friend, you see now why the young man was promoted over you." This illustrates the tendency of our times, for we are rapidly advancing into an age when concentration of energy and grasp of a subject in detail in the shortest possible time are requisite for advancement.

This is largely an era of material progress, and the training which is needed most for the rising generation—especially here in the West—is that which will fit it for the application of its best efforts to the noblest purposes of life. The preparation for this work must come through our schools. Teaching here involves three distinct processes: instruction, or the imparting of knowledge; education, or the development of the faculties; and training, or the formation of habits of thought and work. The master teacher has a happy combination of these three processes, no matter whether it be in the primary grades, the college, the university, or the technical school. In the elementary schools instruction necessarily predominates; in the college and university, the educational; while in the school of technology, the element of training is the most important. And I believe that the principal work of a technical school like this should be the training of young men in accurate methods of thinking and working.

Too many of our teachers in all grades of schools confine themselves too closely to the element of instruction, and many of them fail to recognize the importance of education and training. This is, perhaps, owing to the delicacy which the instructor's work assumes in the educational stage. Here the teaching should be full of suggestions and sympathetic guidance to develop the reasoning faculties and guard them against inaccurate and discursive habits. In the technical school there is a certain amount of preliminary instructional and educational work that must be done, without which no real progress in thorough and systematic training can be made. But this is a condition, I think, that is not fully appreciated by some of our technical schools. While I believe most thoroughly in elementary instruction and advanced education, I fear that too many of our higher institutions of learning neglect the importance of scientific drill, discipline, and mental gymnastics, on which the development and value of the mind as an instrument for the acquisition of real knowledge so much depend. Wrongly directed education, often so painfully acquired, lies like rubbish in the mind; it can not take root and quicken into life and grow, for the means are mistaken for the end, the working machinery is mistaken for the finished product. The great difficulty lies in too many young men to-day being overtaught in the hypotheses and undertrained in the realities of life. We need more practical education and training, and possibly less speculative philosophy. This is demonstrated by the outcry that comes to us from Germany against overeducation. But there is certainly not too much practical education: generations will come and pass away before there will be danger of that. Still, this protest, coming as it does from one of the most intellectual countries of the world, where speculative philosophy flourishes most, will have its reaction in our leading institutions of learning, and will give us a deeper appreciation of practical education.

The present educational methods being inductive and reflective, pertain more to the realities of life and less to its graces than the theories held half a century ago. The new education teaches us that it is unwise to spend the best years of one's life pursuing studies that are merely cultural, for most of us certainly have as much need of knowledge as of culture. We send our children to school to seek for knowledge, for we know that when they study for the love of knowledge culture will come as an incident in the attainment of it. The thing formerly considered was only mental discipline, and the result was depression; while the object now is to keep the mind alert, expectant, and enthusiastic by presenting the delights and rewards of learning. We now teach our boys to realize the activities of their own senses, to see that knowledge only comes to them through these avenues,

and only as it thus comes is it entitled to be considered real knowledge. We now study subjects for what there is in them, so that the knowledge gained may be a help to thought; and the enthusiasm thus acquired begets new ideas. The youthful mind requires something tangible to grasp, or the reasoning faculties are slowly developed. In all scientific works, facts are used as an index to ideas, which is not a tax upon memory, but a stimulus to the intellect. Still "it is not for its facts, but for the significance of its facts, that science is valuable."

The time is forever past of the old idea that the study of the ancient classics, mathematics, and humanities is the only education. And the once popular notion that a broadly educated man is a sort of intellectual reservoir that can be tapped for all sorts of miscellaneous information is equally absurd. The social consideration which once attached to persons supposed to know Latin and Greek, whether gentlemen or not, has been abandoned, and the test of social rank now is what they are and not what they are supposed to be.

The benefits generally claimed to come from a classical education are that it affords an admirable intellectual training, opens up a magnificent literature, and contributes very largely to the right understanding of our native tongue. This is certainly all true, but such intellectual training is derived as easily from other sources, for when the modern languages are taught systematically they are useful in the same way, if not in the same degree; while the natural and physical sciences are admitted now by our best thinkers to be the most powerful agents in the development of the intellect. Their literature, to the great majority of university men is unknown; but the scholar who has laboriously studied for a dozen years or more over his Virgil and Sophocles is generally but little better acquainted with ancient literature than he who has spent a year upon adequate translations of the famous originals. And the understanding it gives us of our own language, which in utility means accuracy, grace, and ease of expression, might, I dare say, be more easily attained in boyhood through formative habits, if guided scientifically, rather than through the endless mysteries of syntax and inflection.

The study of the classics is no longer essential, except in traditional schools. A well-known New York book merchant recently said, when asked about the demands for works on Latin and Greek: "We keep very few of the classics, and it doesn't pay to stock up any more. There is absolutely no demand for them, and a perfectly equipped bookstore can be sustained nowadays without a single classic on the shelves. Probably five times a year we have a call for one, and it doesn't pay to keep a stock for these stray demands." How many modern orators employ quotations from

Cicero, Demosthenes, or Plato? Probably not one in a hundred. But formerly, when Emerson, Phillips, Holmes, Everett, and Alcott were on the lyceum platform, it was necessary for those who heard them to have a knowledge of the classics to intelligently follow them. Times have changed and the natural and physical sciences have taken their place. These offer the greatest advantage in holding the student's attention, stimulating thought, and cultivating the spirit of true investigation; they require the strictest habits of observation, induce concentration, arouse energy, educate the senses, train the hand to delicate manipulation, quicken the faculties of reasoning and powers of judgment; and the varied and useful information which they afford is given in the clearest and most convincing form. When pleasure and desire of learning are fostered together under these influences the amount of knowledge gained will be proportional to the time and opportunity for study.

In science, the student feels that rules are merely summary expressions of a number of concrete facts; and he familiarizes himself with methods of proof, and accepts only that which is susceptible of proof. It is in this way that the sciences become one of the most important means at our command for moral and intellectual training. When studied in a reverential spirit they develop the most intense desire for truth and inculcate an equal hatred for all pretense and falsity and an intolerance of all dogmatism and bigotry. They offer the same evidence for acceptance that they demand for conviction; and in the facts which they discover every theory is tested by being put on trial. All true scientific structures are builded on knowledge and not on faith, on proof and not on current opinion, for all opinions, preconceived notions, hypotheses, and even accepted doctrines are held in abeyance until the evidence is in and has been duly weighed. That mind and manhood are thus trained alike in a pre-eminent degree by the systematic study of the sciences is now beyond dispute. Many of the older classical colleges have abandoned some of their traditions to make room for these comparatively modern studies, which shows how general has become the appreciation of science as a means of intellectual and moral training, when taught by the laboratory method.

But beyond all these acquirements is the judicial attitude of mind which comes as a supreme characteristic of scientific study. In his investigations the true scientist endeavors to present absolute fairness toward all evidence and offers no resistance to its conclusions. His mind thus opens itself to all the avenues of truth, and he welcomes all the results of his investigations with equal cordiality.

Owing to peculiarities of the eye, ear, and brain, investigators

of equal intelligence, training, and experience in their conclusions will generally differ from one another by a constant or nearly constant quantity, and each will differ from the truth. This difference from the truth in each individual is his personal equation or habitual error. Many investigators now correct their results for this constant error, but nowhere in the realm of knowledge are the processes for making this correction so perfectly worked out as in the physical sciences, geodesy and astronomy. A party of astronomers was once about to be sent on service to the southern hemisphere. Their personal equations were carefully ascertained, when it occurred to one of them that in the hemisphere to which they were going the apparent celestial movements would be reversed, and that their errors ought to be reinvestigated for stars of apparent reverse motion. This was done, when the differences were found to be oppositely as large as before. There was, however, one individual in the party to whom it mattered not which way the stars moved, for he had no personal equation in either case.

It is the duty of the scientist to sift facts from theory, and he who is thus engaged constantly in separating what is really known from belief or mere theory gains intellectual strength and an appreciation for true honesty. The ability to weigh evidence and distinguish between it and the flights of the imagination is the natural foundation of greatness in all scientific work; and in proportion to his ability to rise into this lofty realm is a man's opinion and work entitled to authority.

The natural and physical sciences demand our attention on account of their technical applications in the arts, and the admirable preparation which they give for all practical work when concrete things are the objective study. The colleges that teach pure mathematics, languages, history, and philosophy, without their application to the affairs of mankind, do not get beyond the threshold of education. They merely place in their students' hands tools for work without training them in their uses, or to appreciate the variety and beauty of their finished product. It is certainly a high and responsible calling to instruct young men from text-books in what has long been accepted as truth, but the higher functions of a true education rise into the sphere of application and original investigation; and I believe the few institutions that strive to this end are doing more for the real intellectual advancement of mankind than all the traditional schools on record. Without the application of the instruments of knowledge, the pretense and self-stultification born in the class room often result in the dangerous and pernicious idea that it is better to be brilliant than to be sound, better to rely on opinion and faith than on experiment and knowledge. Too

many of our classical colleges are yearly grinding out their grists of such intellectual chaff, for it would seem that the higher university classical education often unfits its recipients for anything except routine work, and they crowd into and often dishonor the so-called learned professions, and then make their living in questionable ways, or starve. In the great cities of Germany the poor boards are constantly called upon to relieve men of the highest classical training, because they can not make a living in their chosen field of work, and are unfitted for the trades and arts. Horace Greeley must have had in mind this kind of education when he exclaimed, "Of all horned cattle, deliver me from the college graduate!"

The colleges that accomplish the most good turn the students' attention to the demands of the times, and thus fit them for the most honorable walks of life. One of the supreme advantages that is derived from a technical education is that it does not unfit men for labor; but from its very method of acquirement—the laboratory—it teaches us that labor is the highest application of the intellect, and the only perfect means of acquiring real knowledge. Nor are the rewards of scientific education to be undervalued, and the industrial opportunities of the scientist to be overlooked.

The wonderful progress in the development of the natural and physical sciences has come through the agency of experiment and comparison. In this, the scientific method, the student at his home masters the text-books; in the library and reading room he studies the works of the best authors and investigators; in the lecture room he is drilled in theory and application; and in the laboratory he puts questions to Nature and receives her replies; and thus develops strength in all the faculties of a true investigator. Liebig, in chemistry, was the first to adopt teaching by experiment about fifty years ago; but other scientists, one after another, have since adopted the laboratory method, until it is now advocated in language, philosophy, literature, and even law.

The exigencies of modern progress in the arts demand that technical institutions of learning shall keep abreast of the times, and this is especially true in regard to schools that profess to turn out practical chemists, geologists, mining engineers, and metallurgists, thoroughly equipped to take immediate charge of important enterprises, or to advise as to investments in new and untried fields. The advances which are now being made in the practice of analytical and industrial chemistry and metallurgy, and in nearly all allied industries, are so rapid that methods described in text-books written for the use of students often become obsolete by the time the books are published.

The training of the specialist requires the most stimulating influences, and the process should be one of continuous and well-directed effort. If we learn, step by step, what Nature has in store for us, without hurry, we incur a minimum cerebral fatigue and a maximum acquirement. A strong constitution is required for successful work in any pursuit. The natural and physical sciences promote this because their study begets cheerfulness; they make life pleasant and interesting, and instead of injuring the nervous system as many other studies do, they give it tone and vigor in much the same way that manual exercise gives strength to the muscular system.

I believe that in some of our technical schools which provide for the most thorough and scholarly study of principles directed immediately upon the useful arts, and rising in their higher grades into original investigation and research, is to be found the ideal education for young men. Too long have these institutions been branded as furnishing only an inferior education to the so-called liberal arts, because it is practical and useful. Too long have they been regarded as furnishing only an inferior substitute for the classics, and their graduates have been spoken of as though they had acquired the art of livelihood at some sacrifice of mental development and intellectual culture. It is true that form and style may be sacrificed in the earnest, direct, and laborious endeavor of students of science, but that all the essentials of intellect and character are happily developed in these schools is thoroughly demonstrated by the eminent success of their graduates. When measured by the only true standard of intelligence, that of use in the world, these men will rise through their work and power of gaining knowledge to high positions of usefulness and influence.

The demands of the times have forced us to a high appreciation of specialization in all departments of knowledge, and he who attempts on general attainments to cope with advanced problems in practice generally meets with defeat in much of his work. A mere smattering of knowledge no longer suffices in professional pursuits, and the proverb—

> "A little learning is a dangerous thing;
> Drink deep, or taste not the Pierian spring"—

is too often realized by those who attempt work for which they are not fitted by professional training, or by those who have scattered their capacities over widely diversified fields. The weakest individual, by concentrating his energies on a single pursuit, may meet with success; but the strongest, by distributing his powers over many, may and often does fail to accomplish anything. Berzelius said that he was the last general chemist, and the single

science of chemistry has grown to such enormous proportions that no one since his day has ever attempted mastery of the whole field. This being true, what can be said of the vast field of all natural and physical science? Those who attempt to cover it, or even a goodly portion of it, can not get much beyond the nomenclature used. The best results are always accomplished by co-operation and differentiation in work. The material progress of our times is due largely to the division of labor, which thus enables each individual to perfect his own skill. In my work as a chemist and metallurgist I am compelled to have a general working knowledge of all allied sciences, but by taking the results of the investigations of my fellow-workers, each in his own field, I am enabled to give more of my time to my own specialty, and therefore to accomplish what I could not do were I "a Jack of all trades." And it may be hoped that my investigations will in their turn come to the aid of the sanitarian, the pathologist, and the engineer. But more than this is required in this day of sharp competition, for it is becoming necessary for the specialist, not merely to confine himself to one subject, but to know more about some particular branch of his subject than does any one else. Those who pursue these special lines are the real investigators, and they give us the advanced scientific knowledge which we now enjoy.

The opportunities of the specialist are many and inviting. Every field of technical work opens up a magnificent series of unsolved problems, the solution of which will bring honor to the discoverer and benefit to the world. Technical chemistry, applied electricity, and metallurgy are yet in their infancy, but what grand achievements they have already made! Many of the greatest advances in modern civilization and the comforts of life have come through these channels. The brain and hand of the trained scientist transform the crude materials of the three kingdoms of Nature into things of beauty for the wants of men. The clay in the bank, the ore in the mine, the wood in the forest, by passing through his hands, take on the form of his thoughts and become expressions of his skill and power.

Specialization in knowledge carries innumerable advantages with it. The thoroughly educated scientist is acquainted with the ablest writers in his field, and reads and comprehends them. He appreciates their ideas and employs their knowledge and experience for his own purpose. If he decides that a process is imperfect, he knows in what direction improvement is needed. He is not misled by undetermined elements or impracticable theories, but through his knowledge of facts bases his conclusions on substantial grounds. He is prepared for any emergency and adapts himself quickly to his surroundings, for his scientific

training enables him to apply himself in practice with the least difficulty and to the greatest advantage. Those who are trained in this way are always in demand, and their valuable services bring the highest financial returns.

Finally, I advocate technical education and specialization, because I believe that they are the most perfect means of securing good citizenship; for when the head and the hand are properly trained, the heart will respond to the noblest dictates of truth and virtue. But in addition to these attainments, I also believe implicitly in the broadest and most scholarly education in all that is useful and good. The specialist, as I have described him, feels the need of broad scholarship for its professional utility. In a court of justice an expert frequently calls into use sciences that have only a remote bearing upon his profession, as well as to present to the court the breadth of his scholarship and his experience. In one case a chemist may in the examination of an ore be called upon to use his knowledge of mining, metallurgy, mineralogy, and geology; in the examination of a drug he may be required to have a knowledge of pharmacy, botany, materia medica, and therapeutics; in another case his examination of a water may call into use a thorough knowledge of physics, pathology, and sanitation; while in another case of suspected criminal poisoning, when the life of the accused may rest largely in his hands, he is required to have a profound knowledge of the details of toxicology, jurisprudence, and microscopy. In fine, the sciences are so blended that a profound knowledge of one can only be acquired through the instrumentality of all the others, and the expert in the course of his professional experience will be called upon to bring into use all the various departments of useful human knowledge. Education for such professional service is a knowledge of how to use the whole of one's self, to apply the faculties with which one is endowed to all practical purposes. A liberal technical education broadens our views, removes prejudice, and causes us to welcome the views of others, and we no longer consider our methods the only ones worthy of adoption. It keeps us out of ruts and makes us desirous of being benefited by the experiences and teachings of others. It stimulates great mental activity, and thus leads to skill, investigation, discovery, and improvement.

It is proposed by a M. Lotz to apply photography to the testing of bridges. Photographs are taken from a convenient spot, of the bridge unloaded and of the same weighted with the heaviest burdens it is intended to carry. The difference in the appearance of the photographs will show the extent to which the bridge yields or sags under the loads put upon it.

PARASITIC AND PREDACEOUS INSECTS.*

By C. V. RILEY, Ph. D.

THE importance to man, and especially to the horticulturist, of the parasitic and predaceous insect enemies of such species as injure vegetation has been recognized by almost all writers on economic entomology. Indeed, it is a question whether the earlier writers did not attach too much importance to them, because while in the abstract they are all essential to keep the plant-feeding species in proper check, and without them these last would unquestionably be far more difficult to manage, yet in the long run our worst insect enemies are not materially affected by them, and the cases where we can artificially encourage the multiplication of the beneficial species are relatively few. While fully appreciating the importance of the subject, therefore, it is my purpose in this paper to point out the dangers and disadvantages resulting from false and exaggerated notions upon it.

There are but two methods by which these insect friends of the farmer can be effectually utilized and encouraged, as, for the most part, they perform their work unseen and unheeded by him, and are practically beyond his control. These methods consist in the intelligent protection of those species which already exist in a given locality, and in the introduction of desirable species which do not already exist there.

In a few cases like this there is no reason why the farmer should not be taught with advantage to discriminate between his friends and his foes, and to encourage the multiplication of the former; but, for the most part, the nicer discrimination as to the beneficial species, some of the most important of which are microscopically small, must be left to the trained entomologist. Few of the men practically engaged in agriculture and horticulture can follow the more or less technical characterization of these beneficial species, and where the discriminating knowledge is possessed it can, as just intimated, only exceptionally be turned to practical account.

In other cases much good may be done without any special knowledge of the beneficial forms, but as a result of a knowledge of the special facts, which enable the farmer materially to encourage the multiplication of parasitic species while destroying the plant-feeding host. Very good illustrations of this kind of work are afforded by the rascal leaf-crumpler and the common bag worm, both of which in the larva state live in cases, and

* Condensed from a paper read before the Association of Economic Entomologists at Madison, Wis., August 15, 1893.

are much affected by parasites, and neither of which can survive if the cases are plucked in winter and placed away from any trees or shrubs, while under these circumstances the parasites will perfect and escape.

It is quite different with the second method of dealing with beneficial insects which I have mentioned, for here man has an opportunity of doing some very effective work. It is only within comparatively recent years that the importance of this particular phase of the subject has been fully realized. Various more or less successful efforts have also been made, and the transmission from one place to another of certain parasites of the plum curculio; of certain parasites of the common oyster-shell bark-louse of the apple; the successful colonization in France of a certain mite which attacks the grape phylloxera; the efforts to send parasites of plant-lice from Europe to Australia; the introduction into this country of *Microgaster glomeratus*, a common European parasite of the cabbage worm, and of *Entedon epigonus*, a common European parasite of the Hessian fly—are matters of record in State and Government publications.

In 1887 and 1888 the now well-known importation of *Vedalia cardinalis* from Australia and New Zealand to California to prey upon *Icerya purchasi* was successfully carried out. The history of this striking example of the beneficial results that may in exceptional cases flow from intelligent effort in this direction is now sufficiently well known to American economic entomologists, but anticipating that we shall have foreign delegates among us, and that our proceedings will be published more widely than usual, it will perhaps be wise to give the salient historical facts in the case, even at the risk of some repetition of what has been already published.

The fluted scale, otherwise known as the white or cottony-cushion scale (*Icerya purchasi* Maskell), is one of the largest species of its family, and up to 1883 had done immense injury to the orange groves and to many other trees and shrubs of southern California. From Australia, its original home, it had been imported into New Zealand, South Africa, and California—the evidence pointing to its introduction into California about 1868, and probably upon *Acacia latifolia*.

In my annual report as United States Entomologist for 1886 will be found a full characterization of the species in all its stages; but the three characteristics which most concern the practical man and which make it one of the most difficult species to contend with are its ability to survive for long periods without food, to thrive upon a great variety of plants, and to move about throughout most of its life.

The injuries of this insect, notwithstanding the efforts to check

it, kept on increasing, and some ten years ago I felt that the work of this particular species and of others which seriously affected the fruit-growing interests of southern California, justified the establishment of agencies there. Up to this time no special entomological efforts have been made by the Government on behalf of the fruit-growers of the Pacific coast. Through agents stationed—the one at Los Angeles, the other at Alameda—a course of elaborate experiments was undertaken as to the best means of treating the insects affecting the orange there, and more particularly this fluted or cottony-cushion scale. During the progress of these investigations, however, the fact impressed itself upon my mind that we had here an excellent opportunity of calling to our aid its own natural enemies; for while there were at first some doubts as to the origin of this icerya, the question was finally settled to my satisfaction that it was of Australian origin, that in its native home it was not a serious pest, but was kept subdued by natural checks.

A clause in the bill appropriating for the division of entomology prohibited the sending of agents abroad and prevented at the time independent action by the Department of Agriculture; but with the co-operation of the Department of State an arrangement was finally made by the Hon. Frank McCoppin, United States Commissioner to the Melbourne Exposition, whereby two agents of the Division of Entomology were sent to Australia, one of them specially charged with the study and importation of the natural enemies of this insect.

It was thus that Mr. Albert Koebele, in the fall of 1888, was sent to Australia for this special purpose. The history of Mr. Koebele's efforts has been detailed from time to time in Government publications and in the press, especially that of California. It suffices to state that a number of living enemies, both parasitic and predaceous, were successfully imported, but that one of them (*Vedalia cardinalis*) proved so effective as to throw the others entirely into the shade and render their services really unnecessary. It has so far not been known to prey upon any other insect, and it breeds with surprising rapidity, occupying less than thirty days from the laying of the eggs until the adults again appear. These facts account for its exceptionally rapid work, for in point of fact within a year and a half of its first introduction it had practically cleared off the fluted scale throughout the infested region. The expressions of two well-known parties may be quoted here to illustrate the general verdict. Prof. W. A. Henry, Director of the Wisconsin Agricultural Experiment Station, who visited California in 1889, reported that the work of the vedalia was "the finest illustration possible of the value of the department to give the people aid in time of distress, and the distress

was very great indeed." Mr. William F. Channing, of Pasadena, son of the eminent Unitarian divine, wrote two years later:

"We owe to the Agricultural Department the rescue of our orange culture by the importation of the Australian ladybird (*Vedalia cardinalis*).

"The white scales were incrusting our orange trees with a hideous leprosy. They spread with wonderful rapidity, and would have made citrus growth on the whole North American continent impossible within a few years. It took the vedalia, when introduced, only a few years absolutely to clean out the white scale. The deliverance was more like a miracle than anything I have ever seen. In the spring of 1889 I had abandoned my young Washington navel orange trees as irrevocable. Those same trees bore from two to three boxes of oranges apiece at the end of the season (or winter and spring of 1890). The consequence of the deliverance is that many hundreds of thousands of orange trees (navels almost exclusively) have been set out in southern California this last spring."

In other words, the victory over the scale was complete, and will practically remain so. The history of the introduction of this pest; its spread for upward of twenty years and the discouragement which resulted; the numerous experiments which were made to overcome the insect; and its final reduction to unimportant numbers by means of an apparently insignificant little beetle imported for the purpose from Australia, will always remain one of the most interesting stories in the records of practical entomology.

The vedalia has since been successfully colonized at the Cape of Good Hope and in Egypt, and has produced the same results in each case. In Egypt the vedalia was introduced to prey upon an allied species of icerya (*I. ægyptiacum*). We hope soon to be able to send the same insect to India, where it has recently transpired that *Icerya ægyptiacum* occurs; while recent information received from Phra Suriya, Royal Commissioner of Siam, at Chicago, would indicate that its introduction into Siam for the same or a closely allied insect will be desirable in the near future.

In fact, the success of the experiment was so striking and so important, and resulted in the saving to California of an industry of so great a money value that it has given rise, not only in the popular mind but in the minds of a certain class of entomologists also, to the idea that remedial work against injurious insects should be concentrated upon this one line of action, and that our best hope for their destruction lies with the parasitic and predaceous species, not to mention fungous and bacterial diseases. From an extreme of comparative incredulity the farmer and fruit-grower have gone, perhaps, to the other extreme of too great

faith. The case of icerya and vedalia, as I have frequently pointed out, was exceptional and one which can not easily be repeated.

One of the numerous phases of the vedalia experiment is that the wide newspaper circulation of the facts—not always most accurately set forth—has brought me communications from all parts of the world asking for supplies of the renowned little lady-bird for use against injurious insects of every kind and description, the inquiries being made, of course, under a misapprehension of the facts.

While this California experience thus affords one of the most striking illustrations of what may be accomplished under exceptional circumstances by the second method of utilizing beneficial insects, we can hardly expect to succeed in accomplishing much good in this direction without a full knowledge of all the ascertainable facts in the case and a due appreciation of the profounder laws of Nature, and particularly of the interrelations of organisms. Year in and year out, with the conditions of life unchanged by man's actions, the relations between the plant-feeder and the predaceous and parasitic species of its own class remain substantially the same, whatever the fluctuations between them for any given year. This is a necessary result in the economy of Nature; for the ascendency of one or the other of the opposing forces involves a corresponding fluctuation on the decreasing side, and there is a necessary relation between the plant-feeder and its enemies, which normally must be to the slight advantage of the former, and only exceptionally to the great advantage of the latter. This law is recognized by all close students of Nature, and has often been illustrated and insisted upon by entomologists in particular, as the most graphic exemplifications of it occur in insect life, in which fecundity is such that the balance is regained with marvelous rapidity, even after approximate annihilation of any particular species. But it is doubtful whether another equally logical deduction from the prevalence of this law has been sufficiently recognized by us, and this is that our artificial insecticide methods have little or no effect upon the multiplication of an injurious species except for the particular occasion which calls them forth, and that occasions often arise when it were wiser to refrain from the use of such insecticides and to leave the field to the parasitic and predaceous forms.

It is generally when a particular injurious insect has reached the zenith of its increase and has accomplished its greatest harm that the farmer is led to bestir himself to suppress it; and yet it is equally true that it is just at this time that Nature is about to relieve him in striking the balance by checks which are violent and effective in proportion to the exceptional increase of and con-

sequent exceptional injury done by the injurious species. Now, the insecticide method of routing this last, under such circumstances, too often involves, also, the destruction of the parasitic and predaceous species, and does more harm than good. This is particularly true of those of our *Coccidæ* and *Aphididæ*, and those of our lepidopterous larvæ, which have numerous natural enemies of their own class, and it not only emphasizes the importance of preventive measures which we are all agreed to urge for other cogent reasons, and which do not to the same extent destroy the parasite; but it affords another explanation of the reason why the fight with insecticides must be kept up year after year, and has little cumulative value.

But the problem of the wise encouragement and employment of the natural enemies of injurious insects in their own class is yet more complicated. The general laws governing the interaction of organisms are such that we can only in very exceptional cases derive benefit by interference with it. The indigenous enemies of an indigenous phytophagous species will, *cæteris paribus*, be better qualified to keep it in check than some newly introduced competitor from a foreign country, and the peculiar circumstances must decide in each case the advisability of the introduction. The multiplication of the foreigner will too often involve the decrease of some indigene. If a certain phytophage is generally disastrous in one section and innocuous in another, by virtue of some particular enemy, it will be safe to transfer and encourage such enemy, and this is particularly true when the phytophage is a foreigner and has been brought over without the enemy which subdues it in its native home. Icerya had some enemies in California, presumably American; but they were not equal to the task of subduing it. Vedalia in the icerya's native home, Australia, was equal to the task, and maintained the same superiority over all others when brought to America. The genus was new to the country, and the species had exceptionally advantageous attributes. But there is very little to be hoped from the miscellaneous introduction of predaceous or parasitic insects for the suppression of a phytophage which they do not suppress in their native home or in the country from which they are brought. The results of the introduction by Mr. A. D. Hopkins of *Clerus formicarius* to contend with the scolytids, which were ruining the West Virginia pines, were doubtful, for the reason that the indigenous species of the genus were already at work in America. Yet the experiment was safe and desirable because the European clerus is more active and more seemingly effective than our indigenes. The gypsy moth was evidently introduced into Massachusetts without its European natural enemies, and as in some parts of Europe it is often locally checked by such natural ene-

mies, a great number of which are known, a proper study of them and the introduction of the most effective could result in no possible harm and might be productive of lasting good.

There are two other laws which it is worth while to consider in this connection. One is, that while a plant-feeder's natural enemies are apt to cause its excessive abundance to be followed by a corresponding decrease, yet this alternation of excessive abundance and excessive scarcity will often be produced irrespective of such natural checks. An injurious insect which has been on the destructive march for a period of years will often come to a sudden halt, and a period of relative and sometimes complete immunity from injury will follow. This may result from climatic conditions, but more often it is a consequence of disease, debility, and want of proper nutrition, which are necessary corollaries of undue multiplication. Frequently, therefore, it may be inaccurate and misleading to attribute the disappearance of a particular injurious species to some parasitic or predaceous species which has been let loose upon it, and nothing but the most accurate observation will determine the truth in such cases. The past year furnished a very graphic illustration in point. Throughout Virginia and West Virginia, where the spruce pines have for some years suffered so severely from the destructive work of *Dendroctonus frontalis*, not a single living specimen of the beetle has been found during the present year. This has been observed by every one who has investigated the subject, and particularly by several correspondents who have written to me: by Mr. E. A. Schwarz, who was commissioned to investigate the facts, and by Mr. Hopkins, who has made the study of the subject a specialty. The clearest explanation of this sudden change is, that the species was practically killed out by the exceptionally severe cold of last winter, since such was the case with several other insects. Now, following so closely on the introduction by Mr. Hopkins of *Clerus formicarius*, how easy it would have been to attribute the sudden decrease to the work of the introduced clerus, had not the decrease been so general and extensive as absolutely to preclude any such possibility! In like manner a certain scale-insect (*Aspidiotus tenebricosus*) had become exceedingly destructive to the soft maples in the city of Washington last year, whereas the present year it is almost entirely killed off, evidently by the same exceptional cold. Many of the affected trees were painted with whitewash, with a view of destroying the aspidiotus, and the death of this last might have been attributed to the treatment (and naturally would be by those employing it) were it not that the same result was equally noticeable on the trees not treated. Reports from southern California would indicate that the red scale (*Aspidiotus aurantii*) is in many orchards losing its destructiveness

through agencies other than its insect enemies, and in this case the facts are particularly interesting, because of the ease with which its disappearance may be attributed to some of the recent introductions from Australia.

The other law that is worth considering in this connection is that, as a rule, the animals and plants of what is known as the "Old" World—i. e., of Europe and Asia—when introduced into North America have shown a greater power of multiplication than the indigenous species, and in a large number of instances have taken the place of the native forms, which have not been able to compete with them in the struggle for existence. This is still more true of the species introduced from the Old World, as well as from America, into Australia, where the advantage of the introduced forms, as compared with the indigenes, has been in many cases still more marked.

There are some instances in which there can be no doubt whatever as to the good which will flow from the introduction of beneficial species, and an illustration is afforded in the caprifig insect (*Blastophaga psenes*). There can be no question as to the good which would result from the introduction of this species from Smyrna into those sections of California where the Smyrna fig is grown without its intervention, and there are other similar instances which promise well and involve no risk. But I have said enough to show that the successful utilization of beneficial insects is by no means a simple matter, and that discriminating knowledge is required to insure success or prevent disaster, especially in the second category dealt with in this paper. The danger attending introductions of beneficial species by unconsciously accompanying them with injurious forms, or by failure to appreciate the facts here set forth, is well illustrated by the introduction to Europe of our *Peronospora viticola*, of the English sparrow to America, and of the mongoose to Jamaica.

Wherever the importance of the matter leads to legislation what are denominated "political" methods are apt either to control or in some way influence the resulting efforts—too often with unfortunate consequences. We should, as economic entomologists, be on the alert for the special cases where the introduction or dissemination of beneficial species promises good results, and do our best to encourage an intelligent public appreciation of such special cases, while discouraging all that is of unscientific or sensational nature, as likely to mislead and ultimately do our profession more harm than good.

SEVENTEENTH-CENTURY ASTROLOGY.

A CURIOUS book is preserved in the National Library of France, the title of which in English would be New Works of Sieur de Conac, Astrologer, Mathematician, Doctor, and Fortune-teller, Advocate of his Majesty. Treating of the Nativity of Men, their Inclination, and what will happen to them through Life. Paris, 1636. But little else is known concerning this Sieur de Conac, except that he wrote a similar book about women. This sage predicts that "the man who is born on Sunday, which is the house of the sun, will be inclined to many callings, offices, and estates, fond of serving the great, and will acquire means according to his quality. If he is noble, he will converse with kings, princes, marquises, barons, and grand lords, and will increase his lordship in quality and make his house illustrious with more grandeur than belongs to it, and his subjects will serve him faithfully; and he will acquire great fame, be subject to headache, toothache, and quartan fever, will be in danger of fire, will travel much, will be lucky in buying horses, and loved by women, and will be married several times; he will not get much from his father, he will be in danger of the plague, and, according to the course of Nature, will live sixty-three years; he will be passionate and sanguine, a little brown and a little red in complexion, and liberal. He will travel much in foreign countries, his secrets will be kept, he will be preserved from his companions and servants, and will make his living by many trades.

"The man born on Monday will have office and authority over the people, will be versed in geometry, arithmetic, and geography. If he is noble, he will receive the rank of king or prince, and will be ambassador, nuncio, or legate; if he is a mechanic, he will be silversmith or goldsmith; if he is in the Church, he will be vicar-general, treasurer, or at least canon; if he is a sailor, he will be captain or master of the ship, pilot or corsair; will be also of phlegmatic nature, subject to catarrhs, will have cross-eyes and toothache, flux, colic, and spleen, swelling of the legs and other parts of the body, and will be hurt in his weak spots. He will be fortunate on the sea, in mills and fisheries, messages, printing offices, most so in agriculture, will be in danger of poison, he will love widows, and will live seventy years. He will be fond of things that come from the water, and will be sculptor, founder, tiller, messenger, or master of fountain and fishes, and will be of fantastic humor.

"The man who is born on Tuesday, his star being Mars, will be hardy, arrogant, threatening everybody, wrathful, a man of good cheer, prompt to attack and ready to meet attack with fire-

arms or other arms, according to the kind of person it is; his vocation will be locksmith, furrier, smith, fabricant of all sorts of firearms; he will be inclined to wantonness, a lover of play, a liar, a swearer, promising one thing and doing another, and will have unrighteous quarrels. In station he may reach the rank of captain, master of the camp, general of the army, chevalier, or Grand Master of Malta, governor of the city, of the castle, or military engineer, mathematician, and on account of his valor will be welcome with princes and lords; will live seventy-two years, and will have only one wife and few children, and will not be in danger of sudden death. He will be a good surgeon, a good anatomist, provost, bowman, sergeant, baker, cook, and violent.

"Wednesday, Mercury's day, promises a man of great mind that he shall be a philosopher, orator, doctor, or astrologer, successful in mechanical practice and arts, as with plants, trees, and merchandise, and may arrive to great dignities, as of ambassador, president, counselor, preacher, orator, good writer, doctor, on good terms with pilgrims, messengers, idlers, vagabonds, counterfeiters, a player with false cards, an adept in occult philosophy, will be wicked with the wicked and good with the good; he will suffer from heart disease, trembling of the limbs, and gouts in the joints; he will have three wives, the change of whom will be good for him; he will have seven or eight children, and will live about fifty years or more. He will be schoolmaster, watchmaker, and instrument maker.

"The star of Jupiter, Thursday, influences a man to great benignity, affability, honesty, discretion, and piety, and to be welcome with princes and kings; he will not be troubled in the courts; and will be rich according to his quality; will be fortunate in marriage, in the service of the prince and great lords, and will reach the quality of nobility or some ecclesiastical dignity; also successful in arms, and with plants, trees, and buildings, minerals, and herbs; and he will profit greatly in voyages, will have a quantity of friends, and will travel in countries where he had no thought of going. If incited by his father or mother, he will have contracts, will be wanton, will have two wives, and many children who will rise in position, and he will live eighty years. He will be a profitable man, liberal, fond of honor, proud, keen, and healthy, affable, jealous of his wives, and will have much knowledge.

"The man who is born on Friday, under the star of Venus, will be by nature very fond of music and of all pleasant things, or will instruct the children of the choir, or will be chapel master, organist, or player of musical instruments, or else a confectioner, glover, perfumer, druggist, or tailor, or something appertaining to

polite exercises; will practice embroidery and other gentle work, will be skilled in making embellishments for women, will marry only once, will have more girls than boys, will love gardens and fragrant things, precious stones, and everything that can adorn the ladies; will be welcome among them, and will live seventy-two years or more. He will be a maker of musical instruments, and a skillful dancer and musician.

"The man who is born on Saturday is apparently solitary, melancholy, and idle, will be glad when his work is done, will suffer in his legs and knees; he will be avaricious, trying to borrow and not return, will go to prison for debts, will be badly dressed for fear of want, and will be subject to rash, gall, and other diseases. In fortune he will have luck in finding treasures, will be rich in inheritances; he will live nearly a hundred years, according to the course of Nature; will addict himself to occult sciences, will be fortunate in solid things like wood, iron, stones, etc., will be fond of many evil things which I will not put down here, there being no need to tell everything. He will be indolent, weak, of bad appearance, lame, poor, ill-formed, if he is not looked upon by the sun or by Venus.

"The whole will be according to the will of God."

Having thus made these wonderful predictions, the Sieur de Conac does not fail to look out for himself, and we read the following little personal item:

"The aforesaid astrologer tells fortunes of the past and the future, reads the disposition of persons in their physiognomy, and sells drugs for the cure of diseases, and has other interesting secrets in his line. The said mathematician lives at Château Gaillard, at the end of the Pont-Neuf, near the Hôtel de Nevers."

This pleasant announcement need not surprise us, for do we not find at the end of this century—this century of progress and light—advertisements in the papers making known to the simple of both sexes that Madame X——, the celebrated cartomancist, predicts the future from the lines of the hand and plays the great game? While the cartomancists of the nineteenth century have their clients, it would be hard to find out why an astrologer should not have had them two centuries and a half ago.—*Translated for The Popular Science Monthly from the Revue Scientifique.*

The Government of Bengal has been induced to impose additional limitations upon the kinds of cases to which jury trial may be applied. It is alleged that the juries allow personal feelings or caste prejudices to interfere with the discharge of their duty. There is, furthermore, some uncertainty concerning the action of a native jury upon such a charge as forging a receipt for taxes. It is pleaded against this measure that sufficient evidence of the necessity for it has not been adduced, also that it is not prudent to withdraw a privilege once granted and exercised.

SKETCH OF GOTTHILF HEINRICH ERNST MUHLENBERG.

THE late Prof. J. M. Maisch, in his memorial oration on Muhlenberg as a Botanist,* laid stress upon the frequency with which his name is met in works of descriptive botany as that of the person who first recognized as separate and scientifically designated some particular genus or species. Waiving all considerations of credit for priority or of personal fame, the leading aim in all Muhlenberg's botanical work seems to have been to assure the precise and accurate definition of the plant with which he was for the moment dealing.

Names of the Muhlenberg family are conspicuous in the history of this country. Its founder in America, Pastor Heinrich Melchior Mühlenberg, who came to Philadelphia by way of Charleston, S. C., in 1742, was known as the patriarch of the Lutheran Church in the United States. His eldest son, Johann Peter Gabriel, also a minister in his earlier life, was a major general in the Revolutionary War, Vice-President of Pennsylvania, six years a member of the House of Representatives of the United States, a United States Senator, and an officer of the revenue. Another son, Friedrich August, who also began his career in the pulpit, was a member of the Continental Congress, a member and Speaker of the Pennsylvania Legislature, and a member of the House of Representatives of the first four Congresses, during two of which he was Speaker.

The third son, Gotthilf Heinrich Ernst Muhlenberg, the subject of the present sketch, was born in New Providence, Montgomery County, Pa., November 17, 1753, and died in Lancaster, Pa., May 23, 1815. He attended schools in his native place and in Philadelphia, whither his family removed in 1761. When he was ten years old he was sent with his brothers to Halle, in order to finish his academic studies and to prepare for the ministry. Arrived in Holland, the brothers proceeded directly to Halle, while young Henry set out in the care of an attendant for Einbeck, his father's native place, where many of his relatives still lived. Deserted on the journey by the man to whose protection he had been confided, this boy, left without money in a strange land, bravely pushed forward on foot and thus finally reached his destination. After his visit to Einbeck he entered a school in Halle, in which he continued about six years. He spent a longer time

* Delivered before the Pioneerverein of Philadelphia, May 6, 1886, and published in Dr. Fr. Hoffmann's Pharmaceutische Rundschau, June, 1886; also separately. It is the principal source whence we have drawn the matter of this sketch.

in the higher classes than was necessary, awaiting the age at which he could be admitted to the university. This he entered in 1769, but remained in attendance only about a year. He returned to Pennsylvania in 1770, and was ordained by the synod of his church and appointed assistant to his father in the pastoral work "at Philadelphia, Barren Hill, and on the Raritan." In 1774 he was called to be the third preacher in Philadelphia. The prominence of his brothers in the Revolutionary councils exposed him to dangers from the British, as they approached the scene of his labors, and he fled, September 22, 1777, not to return till the following year. In 1780 he became pastor of the Lutheran church at Lancaster, where he spent the rest of his life. Mr. Muhlenberg was married, in 1774, to Catherine, daughter of Philip Hall, of Philadelphia. He had two sons; one them, Henry Augustus, won a high reputation, first as clergyman, and afterward in public affairs. The other son, Frederick Augustus, became an able physician in Lancaster, Pa.

His work in botany began during his residence in the country following his flight from Philadelphia. He resumed the study earnestly after his return to the city, and became deeply interested in the less conspicuous flowering plants and the cryptogams. Botanists had not been idle in the study of North American plants. Even before the time of Linnæus Dr. J. Cornutus had published in Paris, in 1635, his History of Canadian Plants, and John Banister his Virginia Catalogue in London in 1688. Johann Friedrich Gronovius, of Leyden, had brought out his Flora Virginica, with the Linnæan classification, in 1739 to 1743, of which his son published a second edition in 1762. To this work John Clayton, who had permanently settled in Virginia, and whose name is preserved in *Claytonia virginica*—our familiar spring beauty—was a contributor. Other botanists who had worked in this field were Mark Catesby, with his Natural History of Canada, Florida, and the Bahama Islands (1731–1743), and his Hortus Britanniæ Americanus (1763–1767); Julius von Wangenheim, with his German Description of Some North American Trees and Shrubs, with reference to German Forests (1781); Humphry Marshall, with his Arbustrum, or Catalogue of American Trees and Shrubs (1785); and Walter, with his Flora Caroliniana. The works of Linnæus also had much matter of American origin, communicated to him by Peter Kalm, Clayton, John Mitchell, Cadwalader Colden, and John Bartram. Most of these works, and others by the older European botanists, were used by Muhlenberg in his studies.

More strictly contemporary with him were the two Michaux—André (1801–1803) and François André (1805–1813); while in the works of Pursh (1814), Shecut (1806), Le Conte (1811), and Bige-

low (1814) is incorporated matter borrowed from the results of his researches.

It thus appears that the field of the present Atlantic Middle States had been explored with considerable energy before Muhlenberg's time. New species of plants had been discovered and additional information had been gained concerning species already known. The scientific value of these observations, attested by the herbariums which still exist, and by what Muhlenberg furnished for publication, is enhanced and interest is added to them by a careful perusal of Muhlenberg's correspondence, a part of which he kept and is now preserved by the Historical Society of Pennsylvania. These letters—some from European naturalists and others from American—were written in the last sixteen years of the eighteenth century and the first and part of the second decades of the nineteenth, and are often annotated with Muhlenberg's remarks. Of his own letters only a few copies are present, chiefly those which he wrote between 1791 and 1794 to Dr. Manasseh Cutler, of Ipswich, Mass. Further, a number of letters from various students and note-books, botanical notices, descriptions, and outlines in Muhlenberg's handwriting are in the possession of his descendants, or have been handed over by them to scientific societies.

The note-books bear witness to the earnestness with which Muhlenberg took up and pursued his botanical studies after his flight from Philadelphia. During the year 1778 may be found numerous descriptions of plants like that of *Eupatorium purpureum*, trumpetseed or gravel root; to which are added such notes as "is probably *Eupatorium* (*altissimum*)." Doubtful remarks of the kind abound. "Is it probably *Actea ?*" "It may be *Azalea ?*" "Perhaps it is *Convallaria ?*" It is evident from such notes that Muhlenberg had not advanced far in acquaintance with the wild plants in the summer of 1778. In the same year he seems to have drawn up a plan of studies by the systematic execution of which he could hardly fail to acquire the desired knowledge. Its most notable points are as follows: "How may I best advance myself in the knowledge of plants? It is winter, and there is little to do. In winter I must select such plants as I can easily remove. . . . Toward spring I should go out and form a chronology of the trees, how they come out, and of the flowers, how they appear, one after another. . . . I should especially remark the flowers and fruit; and there are many other circumstances, but none quite so essential.

"1. The flower, the time, the part of the plant it stands on, whether there are stamens, and how many; the pollen; whether there are pistils, and how many; their shape; whether and how there is a corolla; its color and shape; whether and how there is a calyx.

"2. What sort of a seed, and what kind of a fruit.

"3. How the plant appears otherwise; its root; its stem, if it has any; and its leaves.

"4. To make remarks on the occasional peculiarities of the plant; of my own on the smell, taste, etc., and of what others say, of which one story in a hundred may be true.

"If I could make an herbarium in whole or in part, it would be so much the better. I might plant the more important specimens in my garden. A good friend, who has the knowledge and the disposition to help me, would be of great advantage (Mr. Young, three miles from here).

"Materials to be taken on excursions: An inkstand, with pen and paper, and a box to carry my plants in safely. And when possible, a microscope. Besides the box a few sheets of paper stitched together in folio, in which to lay the plants and carry them; to be tied up in front."

It was not long before Muhlenberg became engaged in correspondence with other botanists. Dr. Johann David Schöpf, an officer of the Hessian troops stationed in New York during the Revolutionary War, who traveled through the Eastern States to Florida, after the conclusion of peace, in search of medicinal plants, became acquainted with Muhlenberg and was assisted by him. After his return to Germany he was the occasion of a correspondence between Muhlenberg and Prof. Schreber, of Erlangen, and this was followed by exchanges of letters with other eminent botanists in Germany, England, France, and Sweden, as well as with Americans.

Like a true naturalist, Muhlenberg continued to exercise the greatest care and thoroughness in observation and research. A botanical excursion and note book of 1785 contains the following plan of work:

"This year I shall again keep a calendar of all plants as I may observe them, especially when in bloom. When I am quite certain, I shall set down only the Linnæan name; when not quite certain, I shall make a full description. Especially shall I try to complete the descriptions of 1789 in those kinds of plants in which many species are most exact. As I very carefully explored this region last year, I shall this year visit other regions, namely: 1. The mountains on the Susquehanna, in May and July. 2. The mountains called Chestnut Mountains, also twice, etc. I must further call upon apothecaries and take other pains to learn the officinal plants, their virtues and their common names. I must this year pay particular attention to the seeds, and especially to describe all herbs as completely and exactly as possible, especially when I am not wholly certain. I shall give particular attention to those of which there are many species, such as asclepias, con-

volvulus, serratula, aster, solidago, and all the ferns. . . . The seed vessels and seeds are very important for the genus and species, and I must therefore give careful attention to them." He also indicates here as one of his purposes, besides the native plants, to observe all the exotics, whether they need protection in winter or are completely acclimated.

In the spring of 1791 he was able to inform Dr. Cutler that he had collected more than eleven hundred different plants in a circuit of about three miles from Lancaster, and that he was devoting himself to the collection of material concerning their medicinal and economical applications. In a later letter, November 8, 1791, he wrote: "I am collecting, as far as possible, all I can learn concerning the medicinal and economical uses of our plants and am writing it down. If the medicinal application seems to be sufficiently confirmed from different sides, and agrees with the character of the plant, I either try it on myself or commend it to my friends. I raise most of the grasses in my garden, and experiment how often they can be cut, and whether they are readily eaten by horses or cattle." These grasses numbered at the beginning of 1798 one hundred and fifty-six species, including many introduced ones, and among them were a large number of new species and at least one new genus. This collecting and testing of grasses is mentioned in other letters. An exchange seems to have been arranged with Prof. Schreber, of American plants for foreign grasses; and, besides mosses, grasses of New England were obtained from Dr. Cutler, especially such as grew near the sea.

Some of these notes on the medicinal properties of plants, Muhlenberg says, were furnished to Dr. Schöpf for use in his contemplated work on American *Materia Medica*. Although the author of that work, which was published in 1787, acknowledged indebtedness for information to several other American botanists, he does not give Muhlenberg's name—a most ungrateful omission. A similar case occurred in connection with an American book. When Muhlenberg first saw a copy of Bigelow's Medical Botany, he could not help remarking to his son, after looking through it, "This gentleman has appropriated to himself all my explanations, without making any acknowledgment." But he never called public attention to this, and there were other such trespasses which were also let pass unnoticed.

In July, 1785, Muhlenberg communicated to the American Philosophical Society an outline of a *Flora Lancastriensis* (flora of Lancaster) containing the results of his own observations on the plants and their habits. At the same time he presented a manuscript Calendar of Flowers. In February, 1791, he communicated the *Index Flora Lancastriensis* (Index to the Flora of Lancaster). This was published in the third volume of the first

series of the Transactions of the society. It is arranged according to the Linnæan system and contains four hundred and fifty-four genera with nearly eleven hundred species, including both wild and cultivated plants. Of the naming of these plants, Muhlenberg remarked in a note: "When I found no name in Linnæus's system, I took a name from other recently published works, or from the letters of Dr. Schreber, with whom I kept up a correspondence. When I found no name in this way, I was obliged to give one myself and to add to it N. S., till better information came from more capable botanists." The cryptogamous plants are represented in this index by twenty-five genera with one hundred and twenty-five species. The work, as its name implies, consists merely of the enumeration of the species observed, without description or indication of their habits or uses. A supplement to this index, presented to the American Philosophical Society in September, 1796, and published in the fourth volume of its Transactions, contained forty-four additional genera with sixty-two species of phanerogams, of which nine were hitherto unknown species of grasses; while the cryptogams were further represented by two hundred and twenty-six additional species, belonging to twenty-nine genera.

Muhlenberg perceived very early in his botanical studies how great confusion was likely to arise if names were conferred upon plants supposed to be new, without considering whether they might not have been previously identified and named by others. We have already described the painstaking care he took in his own notes to find the correct names of his specimens. While he was critical of the work of others, he was always ready to recognize their merit, and to make allowance for their imperfections. He wrote to Dr. Cutler of his work on the Useful Plants of New England that, although the author regarded it as immature, "it was of great use to me, and I was very much pleased with it. Every beginning will be imperfect, especially in a new country, and I have not yet read any botanical work without errors. Even Linnæus's works, which were prepared with so much industry, are full of them." In another place he wrote: "Herr Aiton,* in my opinion, makes too many species out of varieties; for instance, his asters and goldenrods. We must expect such things when descriptions are made from specimens taken from a garden instead of from their natural habitats, where plants grow numerously and in various soils." Other criticisms of similar tenor may be taken from his letters, all made from the point of view of exactness in identification and description.

Freedom from self-glorification and from solicitude for the

* In his Hortus Kewensis, 1789.

recognition of his work are patent in all his writings and transactions. When Dr. Barton announced, in 1791, his illustrated Flora of Pennsylvania as in preparation, Muhlenberg concluded that as that author had seen his manuscripts and herbarium, it would not be necessary for him to publish anything except a few additional notes which he might make during the year, and a Floral Calendar. "Excuse my enthusiasm for science," he wrote to Dr. Cutler, in 1792, "which has given me so many pleasant hours, and which, I know, has been cultivated by you with great success. Botany needs your co-operation, and when you have prepared a full table, please leave a few fragments for me." It was this readiness to give credit to the merit of others, combined with his clear vision of the confusion that threatened to arise from the continuance of planless labors, that decided him as early as 1785 to bring out a plan for common labor in making up the Flora of North America. He came to the Philosophical Society again in 1790 or 1791 with this plan. "I repeat," he writes, "my formerly expressed desire that a number of my learned countrymen should unite in botanical investigation and send in their floras to the society for revision and publication, so that by combination of the floras of the different States we may obtain a flora of the United States which shall rest on good and definite observations." While this plan was not carried into execution through the medium of the American Philosophical Society, Muhlenberg again and again returned to it in his extensive correspondence. Thus he wrote: "Others should do the same (that is, search out the flora of the neighborhood of their homes), and, after collecting material for a dozen years, let a Flora of North America be written." Further, "I first sent in a sketch, and in 1790 an index of all the plants that grow here, in the expectation that my botanical friends would join in working up the floras of their several States, so that in about ten years a more general work might be undertaken." And in another place: "If the botanists continue to proceed in the way they are going, in a few years all will be confusion. In order to be sure, we should confer with one another. For this purpose I have printed my Index before publishing full descriptions." A letter to Dr. Cutler, of November 12, 1792, goes more into particulars; it reads: "You have made the beginning of a Flora of New England, and all friends of botany wish that you would go on and complete the work. Let each of our American botanists do something, and the wealth of America would soon be recognized. Michaux should do South Carolina and Georgia; Kromsch, North Carolina; Greenway, Virginia and Maryland; Barton, New Jersey, Delaware, and the lower parts of Pennsylvania; Bartram, Marshall, and Muhlenberg, each his neighborhood; Mitchell, New York; and you, with the Northern botanists, your States. How

much might then be accomplished. If, then, one of our younger associates—Dr. Barton, for instance, whose specialty it is—would combine the different floras into one, how pleasant it would be for the botanical world! I have written to nearly all the persons named above, and hope to receive their concurrence. Let me know your views about it." Dr. Cutler gave the scheme his unreserved approval.

This plan was not carried out. Instead of it, André Michaux worked the combined collections of his eleven years' travels in the United States, through the French botanist Richard, into a Flora of North America, and it appeared in Paris in 1803, one year after the author's death in Madagascar.

The publication of this flora did not change Muhlenberg's view of the necessity of comparative work in co-operation, and in order to bring it a step nearer he decided in 1809 to write a catalogue of the then known native and naturalized plants of North America (*Catalogus Plantarum Americæ Septentrionalis, huc usque cognitarum indigenarum et cicurum*), the printing of which was finished after nearly nine months of work, at the end of July, 1813. While Michaux had described about fifteen hundred flowering plants and ferns, Muhlenberg was able ten years later to exhibit more than double the number of species, and besides these to add, from specimens mostly collected in Pennsylvania, 175 mosses, 39 liverworts, 32 algæ, 176 lichens, and 305 fungi, in all 727 species. The *Compositæ* comprised in Michaux 193 species, in Muhlenberg 410.

Muhlenberg conscientiously named not only the books which he had used in the determination of his collected plants, but also the twenty-eight correspondents in different parts of the United States who had assisted him in his researches by sending plants or seeds. The work gives, besides the botanical and English names, only the numbers of the several parts of the flower, the color of the corolla, the character of the fruit, the locality, and the time of flowering, all as briefly as possible.

At the same time a complete description of the plants growing around Lancaster had been ready to print for years; likewise a complete description of all the other North American plants which Muhlenberg had himself seen and arranged in his herbarium. These descriptions were consequently based entirely on his own knowledge, and had, therefore, especial value. Unfortunately, they have not been published.

A part of one of these works, comprising the grasses, was printed in 1817, two years after the author's death, under the title *Descriptio uberior Graminum* (Fuller Description of Grasses). The manuscript of it was presented by Zaccheus Collins, a friend of Muhlenberg, to the American Philosophical Society in 1831.

The valuable herbarium, for which Muhlenberg collected and sorted for a full third of a century, was bought by a number of his friends for a little more than five hundred dollars, and was presented to the American Philosophical Society in February, 1818. It was then in good condition, but has, unfortunately, not been well taken care of, and has become so decayed as to have little if any more than historical value.

In considering the question of the value to science of these labors of a whole lifetime, we should think first of the greater clearness which resulted from them to the descriptive botany of North America. Although Muhlenberg printed but little, and although he often lost the claim to priority through being anticipated in publication by less reserved botanists, yet we find in Gray's Manual of the Botany of the Northern United States about one hundred species and varieties which were first established as such by him, and besides them a nearly equal number which were either assigned afterward to other genera, or with which, on the principle of priority in publication, the names given by other botanists were retained. This is really an admirable result, considering the zeal of collectors and hunters before and during Muhlenberg's time, and the limited extent of the field which he was able personally to examine. His services have also been well recognized by botanists. A goldenrod was given by Torrey and Gray the name *Solidago Muhlenbergii;* Grisebach named a centaury *Erythræa Muhlenbergii;* a small willow was called by Barratt *Salix Muhlenbergii;* and Gray gave the name *Muhlenbergii* to a species of reed or sedge. Two mosses of the genera *Phascum* and *Funaria* were named after Muhlenberg by Schwartz; two lichens of the genera *Umbilicaria* and *Gyrophora* by Acharius; and a fungus of the genus *Dothidea* by Elliott.

About half of the plant names given by Muhlenberg which are now recognized belong to the reeds and the grasses, *Cyperaceæ* and *Gramineæ*, in the study of which he was supported by Schreber. One of the first new genera of grasses observed by him, to which belong seven species in the Northern floral region of the United States, and a still larger number of other species in the other States and Territories, was given the name *Muhlenbergia* by Schreber. At least five species of this genus, which have not become domiciled east of the Mississippi, are known in Colorado.

This review of Muhlenberg's botanical work would not be complete without special mention of his scientific correspondence, his personal intercourse with naturalists, and the honors he received. Among his foreign correspondents were Dillenius, Hedwig, Hoffmann, Persoon, Pursh, Smith, Schöpf, Schreber, Sturm, Willdenow, William Aiton, of Kew; Batsch, the mycologist; Palisot de Beauvoir in Paris, and Dr. Thibaud in Montpellier; Christian

Ludwig Schkuhr, of Wittenberg, an eminent cryptogamist; Professor and Medical Counselor Heinrich Adolph Schrader, of Göttingen; Kurt Sprengel, professor of medicine and botanist at Halle; and Prof. Olof Swartz, one of Linnæus's most eminent pupils. Among the twenty-eight home correspondents mentioned by Muhlenberg in the preface to his catalogue are the Rev. Christian Denke, of Nazareth, Pa., the Rev. Samuel Kramph, of North Carolina, the Moravian bishop Jacob Van Vleck, and Dr. Christopher Müller, of Harmony, Pa. One of the most valued was Dr. Baldwin, of South Carolina, and Muhlenberg's letters to him have been published by William Darlington, in a volume entitled Baldwiniana. All or nearly all these correspondents were entertained by him in his home at Lancaster, which was open to all students of plants, and was usually visited by them when they came to Philadelphia. Alexander von Humboldt and Aimé Bonpland sought him there on their return from their long sojourn in Spanish America; and Humboldt's letter acknowledging his hospitality is the last which that master in science wrote in America.

Learned societies and institutions likewise covered him with their honors. The University of Pennsylvania gave him the degree of Master of Arts in 1780; Princeton College, that of Doctor of Divinity in 1787. He was elected a member of the American Philosophical Society on January 22, 1785, along with Joseph Priestley and James Madison. Of other societies he received diplomas: from the Imperial Academy of Erlangen, 1791; the Society of Friends of Natural History, Berlin, 1798; the Westphalian Natural History Society, 1798; the Phytographic Society of Göttingen, 1802; the Physical Society of Göttingen, 1802; the Linnæan Society of Philadelphia, 1809; the Academy of Natural Sciences of Philadelphia, 1814; the Society for the Promotion of the Useful Arts, Albany, N. Y., 1815; the Physiographical Society of Lund, Sweden, 1815; and the New York Historical Society, April 12, 1815, not quite six weeks before his death.

Introducing the description of a *Muhlenbergia* in the second volume of his work on the Grasses, Prof. Schreber wrote: "The genus of which this remarkable grass is on account of its beauty and of the particularly curious structure of its organs of fructification one of the most notable species, received its name from me when I published the new edition of the *Genera Plantarum* of the honored Linnæus, after my most revered friend Dr. Heinrich Muhlenberg, evangelical preacher at Lancaster, Pennsylvania, and President of Franklin College there, and also an eminent member of many learned societies; who has, through the discovery of numerous new species and in other ways, rendered immortal service to the natural history of North America, and especially to the knowledge of the plants of Pennsylvania and the other United States."

CORRESPONDENCE.

ARTIFICIAL STIMULATION OF TRUSTS.

Editor Popular Science Monthly:

SIR: On reading Mr. McPherson's paper in your July number, and in view of the present strike, I am more than ever impressed with the social importance of the central idea which I endeavored to set forth in a paper, Corporations and Trusts, sent for your consideration last winter. At this time I desire to call your attention to what seems to me to be an entirely unwarrantable position assumed by Mr. McPherson.

After showing that there is a general tendency toward specialization by the evolutionary working of natural laws, he *assumes* that it has been and is wise to still further specialize by formation of corporations and trusts—that is, by artificial means. On page 296 he says, "This industrial aggregation is a natural and inevitable step of industrial evolution that therefore can not be but beneficial in its final results." *So far as the aggregation is the result of natural laws*, not statutory laws, this may be so; but to the natural aggregation, with the hardships and advantages incident thereto, there has all along been an *unnatural* aggregating power at work. I refer to the laws permitting the formation of corporations for business purposes. I hold that natural processes weed out the weak and unfitted fast enough and with sufficient attendant pain and contention. Natural aggregation and natural competition may be well, and their results on the whole are probably beneficial; but citing facts in proof of these things, or calling our attention to evolutionary doctrines of what natural laws have accomplished, does not even tend to prove that legislative enactments help to produce a beneficial aggregation or specialization. The sociological part of evolution comes pretty near establishing that *all* such enactments are of very doubtful propriety. That the law permitting the formation of corporations for business purposes has been more productive of bad than good results seems to me very probable, and that therefore it is *relatively wrong*, and never intended, *on the whole*, to produce "beneficial results," or "aggregations" that *were beneficial.*

Mr. McPherson certainly fails to show any such beneficial results and proofs thereof. The fact is that natural laws are exact, and the pain and pleasure or both are commensurate, exact, and just, and tend to work beneficially on the whole; whereas any and all legal enactments are more or less *inexact*, and no *such perfect degree of justice, pain, and pleasure follows*; frequently what follows *is almost wholly injustice.*

For the great mass of people to accommodate themselves to this "aggregation" as fast as natural laws would force it is to tax them to their utmost limit of endurance; but when we artificially stimulate this "aggregation" we have passed beyond their power or ability to maintain their peace, and strikes, bloodshed, and untold misery are among the results. Much, if not all, of this open contention and misery would be avoided if only the natural aggregating causes produced effects. It is the *artificial* "aggregating" force of corporations that has so overloaded the national stomach with its "aggregations," combines, and trusts; and now that stomach is in violent upheaval, trying to free itself.

Free competition is well, and so are laws preserving it in peace; but laws which assume to be able to help *natural processes* are and always have been relatively bad, and in some instances very bad.

If legislation permitting the formation of private or business corporations *has increased the aggregating process* and contributed to (or produced) the cause of trusts and strikes—and Mr. McPherson seems to grant that it has, which is just what I attempted to show, among other things, in my paper—then such legislation is something the afflicted classes have just cause to complain of.

The great importance of the question, and the suffering and the pending crisis, are my excuses for calling your attention a second time to this matter; and, also, as I believe, when recognized, errors are not allowed to go uncorrected in your monthly.

I remain very truly yours,

CHARLES WHEDON.

MEDINA, N. Y., *July* 10, 1894.

EDITOR'S TABLE.

SOCIAL DISTURBANCES.

THE events of the last few months in this country have certainly been enough to rouse the most indifferent citizen to serious reflection. In an already depressed condition of industry and commerce we have had thousands of men condemned by arbitrary action to wholly unnecessary idleness, trade in certain sections of the country all but paralyzed by the interruption of communication, and property to the value of millions of dollars destroyed. As an accompaniment to all this there has been considerable loss of life through violence; and the heated passions of men have not stopped short even of the most hideous and diabolical crime of train-wrecking. What further developments the future may have in store for us it is impossible to say; but it is hard to feel hopeful over the prospect unless the public can be got to look a little more deeply into the causes of these troubles than hitherto they have been accustomed to do.

It seems to us that the prevalent habit of regarding such disturbances as arising entirely out of a strained relation between capital and labor is an unfortunate one. Still more unfortunate is it, and still wider of the mark, when emotional people attribute all such troubles to the tyranny of capital. If capital were at all times to give way to the demands of labor, capital would cease to exist, and, population having meanwhile increased in a more than ordinary ratio, general social penury would be the result. Capital may be said, without much abuse of metaphor, to have the same instinct of self-preservation that organic beings have: it will fight for its life. To many people the sight of a capitalist withstanding the demands of his workmen suggests nothing but inordinate selfishness and greed; but this is not the capitalist's view of it; what he feels—we are now supposing a typical case—is that he can not meet those demands without unduly weakening himself and putting his men in the position of getting more than the market value for their labor. We do not say, and are very far from thinking, that capitalists never do selfish things. Still less do we say, or think, that they rise, as a rule, to the level of their social responsibilities; but we wish to affirm our opinion that capital is perfectly justified in acting on that instinct of self-preservation already referred to, seeing that it is a strictly limited quantity and can not without risk of extinction take upon itself the burden of satisfying the ever-expanding desires of mankind. Human desires are like a gas whose volume varies inversely with the pressure to which it is subjected, or, to state it otherwise, which expands just as the pressure acting on it is reduced; and to suppose that one set of men should be able by successive concessions to keep another much more numerous set of men continually satisfied is to suppose what in the very nature of the case is absurd.

Instead of perpetually canvassing the supposed rival claims of capital and labor it would be better if our social reformers would apply themselves to the underlying question how it comes that there is so much competition among the so-called laboring classes for the kind of employment which capitalists supply. The capitalists themselves do not create the competition. If they yielded to all the demands made upon them in the matter of wages and hours, they might be said to do, because then they would be creating conditions which would have a tendency to cause men to rush

into their service. But they do nothing of the kind: as a rule they only yield when they have to, and yet there is generally more labor offering than can be satisfactorily employed. Now, this we consider to be the fundamental social problem of our time; and yet we do not find that it receives anything like the attention it deserves and requires. The labor organizations which play so prominent a part in the modern world seem to assume that labor will always be in excess, and devote their chief efforts to neutralizing by artificial means this natural disadvantage. Their attitude toward capital is thus normally a hostile one, even when actual hostilities are not in progress; and this fact alone may account for not a little of the friction which actually occurs in the practical relations between capital and labor. To be always confronted with a hostile force is not soothing to the temper, and suggests at least defensive, when it does not suggest offensive, measures. It would be better, as it seems to us, if the labor organizations would cultivate less of the militant and more of the administrative spirit, and would use the wide knowledge they must necessarily acquire of the conditions of the industrial world to prevent the overcrowding of particular trades, and, in a general way, to favor such a distribution of the working population as will tend most to their welfare. As long as the capitalist has only to blow his whistle, so to speak, in order to get all the "hands" he requires, the condition of the "hands" will be one of more or less dependence on him; and therefore the true policy of labor leaders is to try to so dispose of the laboring population that they will not be at the beck and call of capital, but will have a much larger measure than at present of social stability and personal independence.

Just how this very desirable result is to be brought about we are not prepared to say; but what strikes us is that if more effort and thought had been devoted by the working classes, organized as they are in unions which permit of their best men coming to the front, to problems of a constructive character, and less to the planning of campaigns and the devising of means by which the least return in labor should be given for the largest obtainable wage, they would have been the better of it to-day. One thing which they should long ago have seen is the desirableness of their complete separation from mere party politics, which, so far as they are concerned, is a simple delusion and a snare. What the workman wants is the simplest and cheapest form of government, and, above all, one under which no exceptional favors will be accorded to individuals or classes. If he is not wise enough to see this, but falls a victim to the special pleading used on behalf of preposterous tariff laws, he can not lay the blame on others; what he wants is understanding, and, until he gets it, he will suffer. A generally higher ideal of life would stand the workman in good stead—an ideal opposed to show and extravagance and favorable to earnest endeavor for intellectual and moral improvement. We are no advocates for "starvation wages"—far from it—but we can not overlook the fact that what one individual considers starvation wages will sometimes suffice for the comfort and self-respect of another, the difference between the two cases being one of personal habit.

As to the capitalist class, there is this to be said, that the man of large means, the large employer of labor who does not interest himself in his men and make the conditions of their labor as profitable and satisfactory to them as possible consistently with a due regard to the stability of his business, is shamefully neglecting the duties which lie to his hand. We have but a limited belief in what is commonly known as philanthropy, but we believe in justice and good will between man and man, and it should not be hard for the capitalist to

determine whether he is doing by those under him as, were he in their position, he would wish, and might reasonably ask, to be done by. This is an age in which luxury runs wild. The capitalist may fairly treat himself liberally; but if he has the true spirit of humanity about him, he will not make of himself a demigod or raise himself to Olympian heights above the people. In saying this we may be as the voice of one crying in the wilderness; but if a message has to be delivered, it is better to cry out in the wilderness than not to cry out at all. Socialism as a system of government fills us with the most profound apprehensions; but, on the other hand, there is a certain socialism of the heart, if we may so express it, which we would gladly do all in our power to encourage—that feeling which leads a man, be his station what it may, to consider that he lives not for himself alone, but for the good of society at large. There is much said about the duties of the rich, but it is doing the rich too much honor to speak and write as if they alone had social duties. The welfare of society depends in the main on the good citizenship of the multitude, and not on anything the rich have it in their power to do. To them also it is given to be good citizens; but the call is not more imperative to them than to those of average or scanty means. It is an old, and ought to be an exploded, fallacy that a single talent is not worth improving. The social millennium will come, if ever, when all the single talents are being improved with a distinct, even if only secondary, aim to the common good.

ENDOWMENT OF RESEARCH.

A RECENT number of Nature contains an article which begins by lamenting the neglect of the British Government to make any adequate provision for the carrying on of physical and chemical research, and then goes on to state that a wealthy manufacturer of high scientific culture, Dr. Ludwig Mond, had purchased for the Royal Institution a spacious building in which to establish physical and chemical laboratories of the most approved kind, and had undertaken to defray all expenses connected with the equipment and maintenance thereof. Now, it seems to us that Dr. Ludwig Mond's action in this matter is highly commendable, and that the action of the British Government in leaving the establishment of such laboratories to private enterprise and beneficence is also commendable. It should never be forgotten that whatever money the Government spends comes from taxation, and that the taxes are levied in great part from the poor. Whether, then, is it better that the Government should spend the proceeds of taxation on such objects as these, or that intelligent and cultivated men like Dr. Ludwig Mond, who have amassed great wealth by the exercise of their talents, should come forward and undertake the duty? We say without hesitation that the latter is far the better solution of the question. If the Government were to do everything of this kind, one of the noblest uses to which private wealth can be put would be at an end. Not only so, but wealthy men would no longer have any interest in studying the needs of the community, and would be left even more than they are at present to indulgence in luxury as the one means of expressing the fact that they are wealthy. If we want to redeem our rich men from the vanity, inanity, and vulgarity of self-indulgence and ostentation, the way to do it is for public opinion to assign them social tasks suited to their means and opportunities; and this can not be done if the Government is asked to shoulder all such responsibilities. All honor to men like Ludwig Mond, who, without any special urging, see what is required for the public good and do it! In this case high intelligence goes hand in hand with

command of pecuniary means; and there is, therefore, reason to believe that what is done under his direction will be well done, and will not be marred or weakened by the perfunctory spirit which so often accompanies state action.

LITERARY NOTICES.

Factors in American Civilization. Popular Lectures and Discussions before the Brooklyn Ethical Association. New York: D. Appleton & Co. Pp. 417. Price, $2.

This volume, the third in the series issued by the Brooklyn Ethical Association, certainly does not fall below its predecessors in interest or the range of its topics. Five of the addresses relate to national life; two lectures are devoted respectively to commerce, the status of woman, and the labor question; while the subjects considered in the remaining three papers are sufficiently diverse—penal methods, charitable work, and the drink habit.

Beginning with the idea of the nation, Dr. De Garmo finds it to be the ultimate unit in civilization. We advance by helping each nation to unhampered development upon its own lines, not by breaking down national barriers. The discussion discloses that Mr. Spencer's idea of government is often misapprehended, especially when drawn from old editions of Social Statics. Our American civilization is, however, the product of numerous factors. The first of these in time, those furnished by Nature, are described by Rev. John Kimball, who agrees with Prof. Shaler that even the boundaries of the civil war may have been determined by the distribution of the Cretacean limestone.

What America owes to the Old World is epitomized by Mr. Palmer as everything except itself. From England we inherit our language, literature, trial by jury, and various institutions; from the Netherlands, our cherished ideas of religious tolerance, popular education, and the freedom of the press. The written ballot is due to the same source, the town meeting is Germanic in its origin; while to Spain, France, and continental Europe we are indebted in other matters.

Dr. Janes shows what the military habit costs us, contrasts the warlike and industrial type, and leads us to question whether the cultivation of the militant spirit pays. Mr. Robert Taylor discourses upon the evolution of railways and illustrates the great progress made in transportation. To move the freight of the United States in 1892 would have required five times the working force of the world one thousand years ago. Foreign commerce is ably handled by Mr. Coombs, and is followed by the inevitable discussion between the advocates of free trade and protection.

An eloquent plea for the political equality of woman is made by Rev. Mr. Chadwick, who remarks that if the objections to woman suffrage could be shut up together by themselves they would dispose of each other. Interesting statistics and suggestions in regard to the economic position of woman are also given by Caroline B. Le Row. Those interested in charities will find a comprehensive paper on the subject by Dr. Warner. Elsewhere in the volume, in an essay upon labor, Mr. Sullivan demands justice instead of charity. From another standpoint Mr. Gilman deals very fairly with the labor question, and without "preaching profit-sharing as a panacea for industrial woes" still recommends it as an improvement upon the wages system. A review of penal methods and institutions is contributed by Mr. McKeen, and an investigation of the drink habit by Dr. Crothers. Finally, philosophizing upon history, Mr. Powell concludes the book.

The discussions following the lectures and the lists of collateral readings suggested contribute much to the value of the work.

The Yachts and Yachtsmen of America: A Standard Work of Reference. Henry A. Mott, Editor. New York: International Yacht Publishing Company. Vol. I. Pp. 692, with Eighty-nine Plates. Price, $15.

This sumptuous work is further defined on the title-page as A History of Yachting and of Yacht Clubs, as well as of the Various Yachts, with Biographies of the Founders and Members of the Different Clubs of the United States and Canada. Yachtsmen of all clubs have long desired to have a work for ready reference, which, besides reliable information relative to the yachts belonging to members of their respective clubs, would give facts

relative to the yachts and yachtsmen of other clubs. The purpose of this book is to supply such information, and in addition to furnish portraits and biographical sketches of persons who have been and are prominently connected with yachting, and of those who have been instrumental in promoting the best interests of yachting, as well as illustrations of the various yachts, with descriptions of the same, their dimensions, capacities, and records. A history is given of each yacht club separately, with a statement of what has been done by its members in promoting the sport of yachting. In the first chapter the evolution of the yacht is described from the beginning with the first presumed attempt of the stone-age savage to propel himself upon a log, through the stages of the catamaran, the hollowed log, the dugout, the birch-bark canoe, the more elaborate canoes of the South Seas and the Indian Ocean, Egyptian, classical, and Viking ships, and the stages of modern shipbuilding to the elaboration of the pleasure boat or yacht of to-day. The history of yachting is next given. Leaving out the ships of Ammon in Jacob's time and the Argonauts' ship Argo, which were business vessels, the first yachts proper on record appear to have been those of Ptolemy Philopater of Egypt and Hiero King of Syracuse. After twelve of the broad quarto pages of the book on the history in general, twenty similar pages are devoted to yachting in the United States. Then follow chapters on the Cost of Yachting and Yacht Decorations; Type of Yacht; Centerboard; Rig of Yachts; Speed Records of Sailing Yachts; Trophies; History; Record of Races; descriptions of yachts and biographical sketches of members of the five leading Canadian yacht clubs, and similar information relative to thirty-eight yacht clubs in the United States. The volume contains more than six hundred photo-etchings of yachts and clubhouses, nearly two hundred half-tone vignettes of yachtsmen, more than forty full-page half-tone portraits of commodores, and a hundred full-page photogravures of yachts and clubhouses. A second volume is to contain a leading chapter relative to the introduction of steam on yachts and to various other motor powers; a history of the America's Cup; histories of such yacht clubs as do not appear in the first volume; and photogravures and descriptions of the vessels, cruisers, and war ships of the American Navy.

Natural Theology. By Prof. Sir G. G. Stokes. London: Adam and Charles Black. Pp. 272. Price, $1.50.

The second course of Gifford Lectures is contained in this volume, the first series of which was delivered and published in 1891.

According to the will of the founder, the subject was to be treated as a strictly natural science, without reference to or reliance upon any supposed exceptional or so-called miraculous revelation.

Prof. Stokes has made no attempt to fulfill this requisition, stating at the close of the course that the conception is hardly possible to carry out in the manner contemplated, and elsewhere that "any divorce between natural theology and revealed religion is to be deprecated." He justifies his deviation from the plan partly by an appeal to another clause in the foundation, suggesting that the lectures should be promoted and illustrated by different minds.

There are ten addresses in all, the first six giving what arguments are offered in favor of theism. The first topic is the theory of the luminiferous ether and the character of the proof for its credibility, a lesson being drawn from this not to reject what transcends sense experience and to provide a favorable reception for the supernatural. Secondly, it is argued, as the simple laws of motion did not account for inorganic phenomena, but to them were added various theories from time to time, such as gravitation and magnetism, so we are justified in assuming some hypothesis for the construction of living matter which physical laws do not fully explain: this is named the theory of directionism. If also this individual directing power be supposed, by whose influence the bodily molecules are brought together, we obtain some notion of survival after death, since it is not subject to physical dissolution.

The exquisite construction of the "bacillary layer" of the retina and the beauty of color and marking found in plants and animals are adduced as evidences of design, and the laws of chemical combination as testifying to some scheme of creation including the

welfare of man. The "vast array of primordial atoms" as well as the beginning of life upon the earth demand the exertion of creative power; this, it is claimed, or even subsequent creative acts, are not in conflict with the process of evolution.

In the remaining lectures the author does not enter upon a comparative study of religions, but confines himself to the claims of Christianity.

Whatever may be said in favor of the theistic arguments contained in the first part of the book can scarcely be maintained in regard to these deductions, wherein it is urged that the Christian doctrine of the origin of man, his fall from a state of innocence, the dogma of the Trinity, and the indwelling of the Spirit "satisfy certain aspirations of natural theology."

The Dawn of Astronomy. By J. Norman Lockyer, F. R. S., etc. New York and London: Macmillan & Co. Pp. 432. Price, $5.

It would be impossible to determine whether the heavenly bodies aroused the greater wonder in the ancients, who could know but little of their real nature, or in us, who have learned something of their immense sizes, distances from the earth, and velocities of motion. That the ancients were profoundly impressed by them, and were attentive observers of their phenomena, is being made more and more evident by the advance of archæological research. While in Greece, some four years ago, Prof. Lockyer became interested in determining the orientation of some of the Athenian temples. He found reason to believe that these structures were oriented upon an astronomical basis, and, carrying the investigation back to the works of the ancient Egyptians, discovered the abundant evidence in support of his supposition which is embodied in the handsome volume before us. The great temple of Amen-Ra at Karnak faces the sunset at the time of the summer solstice. A stone avenue stretches through the axis of the temple for five hundred yards, and throughout all the halls of the building nothing was allowed to obstruct the view through this avenue toward the point where the sun dropped below the horizon on the longest day of the year. Other temples elsewhere were oriented toward the same point. Still others appear to have been oriented with reference to stars. Ruins of old temples have been found and beside them a less ancient structure with an axis pointing in a somewhat different direction. Inasmuch as stars change their declinations about a degree in three hundred years, this circumstance of a changed axis in the new temple strongly supports the theory of stellar orientation. Many similar facts are given by Prof. Lockyer, and in connection with them he sets forth the astronomical basis of the Egyptian pantheon, describes the Egyptian calendar, and constructs, from the various monuments, inscriptions, and other available material, a chronicle of the succession of moon cult to sun cult, and of the mingling of these together and with various star cults, as successive waves of population inundated the valley of the Nile. The volume is copiously illustrated with views of temples and other monuments, figures of gods, diagrams, etc.

Sewage Disposal in the United States. By George W. Rafter, M. Am. Soc. C. E., and M. N. Baker, Ph. B. New York: D. Van Nostrand Co. Pp. 598. Price, $6.

This substantial volume embodies a comprehensive survey of the operations for the disposal of sewage that have been carried on in the United States. The conditions and needs governing sewage disposal in this country being somewhat different from those existing abroad, the authors believe that the information which they have gathered will be of peculiar benefit to American sanitary officials and engineers. The work is divided into two parts, the former of which is a discussion of principles, while the latter consists of descriptions of works. The practice of discharging sewage into fresh-water streams and lakes from which the water supplies of towns are taken has given rise to many of the most perplexing problems that sanitary engineers have had to deal with. Accordingly, the pollution of streams by sewage and manufacturers' waste and the self-purification of streams thus polluted are among the earliest topics treated in this work, their legal as well as their scientific aspects being duly considered. The authors regard as not proved the assertion that polluted streams are rendered fit for drinking by natural agen-

cies in the course of a few miles' flow. They see no objection to discharge into tide-waters or large lakes, and meet the argument as to waste of material by stating that the organic matter in sewage serves as food for low forms of animal life, which in turn sustain food fishes. The various modes of treating sewage—by chemical precipitation, broad irrigation, and intermittent filtration—are then described. Since rye grass, one of the species of useful plants that succeed best on sewage farms, does not cure easily, but may be readily preserved by ensilage, the silo beomes a valuable adjunct to the sewage works. In the portion of the volume devoted to descriptions of works, the establishments at more than twenty places are described with considerable detail and with figures, maps, and diagrams. There are also brief accounts of the use of sewage for irrigation at a number of places in the West. Various laws and codes of rules regulating the disposal of sewage in the United States and England are given in appendixes.

A Handbook of Gold Milling. By Henry Louis. London and New York: Macmillan & Co. Pp. 504. Price, $3.25.

But few arts remain that have not been brought under the sway of science, with the result of securing improved products, a reduction of waste, lessened drudgery for man and beast, or an increased return for the same amount of effort. The separation of gold from the rock and gravel in which it occurs was carried on by wasteful empiric methods so long as rich deposits were available, but now that lower-grade ores must be largely depended upon, a disposition to work in the light of exact knowledge is becoming manifest. The present volume is designed to aid in the technical instruction of gold millers. It gives no space to the separating operations connected with hydraulic mining, the stamp mill being its only theme. After some preliminary chapters on the occurrence of gold, the properties of gold and mercury, and the formation of amalgams, the processes and appliances for the several steps of the modern milling process are taken up in order. Rock breakers, mortar boxes, stamps, frames, guides, and their various accessories are described and are illustrated in views and detailed drawings. The processes of amalgamation, concentration, cleaning-up, and the cleaning, retorting, and melting of the amalgam are then discussed and the appliances required for them are set forth. Some information is given with regard to the cost of milling, labor, power, sampling, and assaying of ore, etc., and several useful tables together with an essay on the cam curve are contained in an appendix.

The Industries of Russia. Prepared by the Department of Trade and Manufactures, Ministry of Finance, for the World's Columbian Exposition. Editor of the English translation, John Martin Crawford, U. S. Consul General to Russia. G. P. Putnam's Sons, New York, American Agents. Five volumes. Price, $6.

The Russian Empire took an active part in the exhibition of 1893 at Chicago. Wishing to afford the American people a fuller idea of the industrial capabilities of Russia than the material exhibit of that country could convey, the Imperial Minister of Finance caused to be prepared this series of volumes which comprise sketches, by especially qualified writers, of the several chief industries of the empire. The first volume is devoted to manufactures and trade, and opens with a general view of this field by the distinguished chemist, Prof. D. I. Mendeléeff, who also contributes papers on the chemical industry and naphtha to this volume. Papers on the various textiles are furnished by N. P. Langovoy, professor in the St. Petersburg Technological Institute, and others on paper, leather, metals, glass, food products, tobacco, spirits, shipbuilding, etc., are contributed by other writers. Of a more general scope are the essays on the interior trade and fairs of Russia, the foreign trade, wages and working hours in factories, tariff systems, etc. The third volume, which is the largest of the five, containing over five hundred pages, is devoted to agriculture and forestry, the various features of these industries being treated by a large number of special writers. Mining and metallurgy are treated in a volume of a hundred pages by Mr. A. Keppen, mining engineer. The fifth volume is devoted to Siberia and the Great Siberian Railway, giving a description of the country and its resources, the history of its occupation by

Russia, and an account of the preliminary work on the railway. The writers of all parts of these volumes have a special acquaintance with their respective subjects through a connection with technical institutions or the Government service. Tables of statistics and many colored maps add to the value of the work.

Elementary Meteorology. By William Morris Davis. Boston: Ginn & Company. Pp. 355. Price, $2.70.

This treatise, which is the outcome of fifteen years of teaching and study in Harvard College may be used either as a text-book or for general reading. It opens with a consideration of the origin and uses of the atmosphere, with its extent and arrangement around the earth. As the winds arise from differences of temperature, the control of the temperature of the atmosphere by the sun is then discussed. The motions of the atmosphere and its varying quantities of moisture are next studied. After this we are led to the discussion of those more or less frequent disturbances which we place together under the name of storms. The closing chapters deal with the ordinary succession of atmospheric phenomena on which our local variations of weather depend, and the average conditions which, repeated year after year, we call climate. Some account is also given of the methods employed in predicting the weather. The text is illustrated with maps, diagrams, and cuts of apparatus.

Appearance and Reality: A Metaphysical Essay. By F. H. Bradley, M. A., LL. D., Fellow of Merton College, Oxford. London: Swan, Sonnenschein & Co. New York: Macmillan & Co. Pp. xxiv + 558. Price, $1.75.

A decidedly ingenious volume, and, to employ a schoolboy term, brimful of "criss-cross" reasonings. Though few names are mentioned, nearly all the great thinkers come under the author's knife. In fact, as the author intimates, to read the work intelligently, one must have read and widely. It is rather favorable than otherwise to allege, of almost every page within the covers, that the reader will doubtless, here and there, discover himself uttering two ejaculations, viz., How does the author know? and, Well reasoned for so ingenious a query! Indeed, at every step we encounter a forest of questions in a field of doubt. At the very opening, the critic is not only disarmed, but Prof. Bradley comes to his own rescue with his own sword, for he "would rather keep" his "natural place as a learner among learners." Hence, "if anything in these pages suggests a more dogmatic frame of mind" he "would ask the reader not hastily to adopt that suggestion. I offer him," he says, "a set of opinions and ideas in part certainly wrong, but where and how much I am unable to tell him. That is for him to find out if he cares to, and if he can." The chief aim of the book is to supply "a skeptical study of First Principles." So, the student, with this in mind, proceeds to ask how can there be, as alleged (preface), any "positive function of the universe," when "outside of spirit there is not and there can not be any reality" (closing lines, page 552); yet withal, "spirit" is nowhere in the book defined, while things around us that are generally accepted as real are (page 127) no "more than mere appearance." These passages detached from the text might constitute a partial injustice were they not the main makes-up of the author's labors. While paradoxes in philosophy are in the aggregate not desirable, they sometimes serve a useful end, and, on the like plane, perplexities in logic may have a place for those who care to pursue the narrow and thorny path to their hiding. One thing, though not stated, is clearly enough perceptible in a perusal of Appearance and Reality: the universe is to each one according to his faculties, and even the earthworm has its world. Instead of taking to the ocean to reach the author's distant shore, he might have landed us in a nutshell across some surer though narrower channel. The work contains twenty-seven chapters, is divided into two books, and constitutes one in Series No. 3 of the Library of Philosophy.

In a lecture on *The Status of the Mind Problem*, Mr. *Lester F. Ward*, of Washington, predicates the dependence of mind and body while carefully avoiding the predication of their identity. Concerning the "mystery of mind," he offers the simple explanation that "the phenomena of mind stand in the same relation to the brain and nervous system that all other phenomena

stand to the substances that produce them; in a word, that the mind is a property of the organized body." Mind is no more a mystery than matter, except that its phenomena being more complex, we possess as yet much less knowledge of them than we do of many of the simpler phenomena of Nature.

The *Report of the United States Commissioner of Fish and Fisheries* for 1889 to 1891 contains, besides the summary of the work of the commission and its different stations, reports by Richard Rathbun of the Inquiry respecting Food Fishes and the Fishing Grounds, and by Hugh M. Smith regarding the Methods and Statistics of the Fisheries; and, in the Appendices, reports, by Z. L. Tanner, on the Investigations of the Steamer Albatross; by C. T. Townsend, on the Oyster Resources and Oyster Fishery of the Pacific Coast of the United States; and by C. H. Stevenson, on the Coast Fisheries of Texas; with papers on the Sparoid Fishes of America and Europe, by D. S. Jordan and Bertt Fisher; Fish Entozoa from Yellowstone Park, by Edward Linton; and Ernst Haeckel's Plankton Studies on the Importance and Constitution of the Pelagic Fauna and Flora (translated by G. W. Field).

A pamphlet by Mr. *Alexis A. Julien*, entitled *Notes of Research on the New York Obelisk*, contains, under the significant title of *Misfortunes of an Obelisk*, a history of the obelisk in Central Park from the time it was quarried at Syene till it was brought and erected in its present position; together with a *Study of the New York Obelisk as a Decayed Bowlder*. The author regards the obelisk as liable to rapid decay in our damp and variable climate, and his chief object appears to be to discover the best means of arresting its disintegration. He approves of the paraffin treatment that has been applied to it, but believes, and seeks to demonstrate, that it was originally gilded; and that if again covered with gold it will be restored to its first estate and be most effectually protected against further deterioration.

From *Romyn Hitchcock*, Chicago, Ill., we have of his contributions to the United States National Museum *The Ainos of Yezo, Japan*—one of the most satisfactory and valuable works on the subject that has appeared; *The Ancient Pit Dwellers of Yezo, Japan; Shinto, or the Mythology of the Japanese; The Ancient Burial Mounds of Japan;* and *Some Ancient Relics in Japan.*

The first paper, and the one occupying the most space, in the *Archivos do Museo Nacional do Rio de Janeiro* (Archives of the National Museum of Rio de Janeiro), is by Dr. Emilio Augusto Goldi, On a Disease of the Coffee Tree in the State of Rio de Janeiro, which is produced by a nematoid worm, *Meloidogne exigua.* Dr. Fritz Müller describes the metamorphoses of *Trichodactylus*, a fresh-water crustacean, and furnishes besides papers on *Janira exul*, an isopod crustacean of the State of Santa Cattarina, and two shrimps—*Atyoida potimirum* and *Palæmon potiuna;* and Dr. Hermann von Shering contributes a description and anatomy of *Peltella.*

The *Journal of Morphology*, under the editorial conduct of Prof. *C. O. Whitman* and Mr. *Edward Phelps Allis*, Jr., continues to furnish the best results of the most careful researches in the branch to which it is devoted. No. 2 of Vol. VIII (May, 1893) contains the second part of Prof. J. S. Kingley's study of The Embryology of Limulus; The Habits and Development of the Newt, by Edwin O. Jordan; The Formation of the Medullary Groove in the Elasmobranchs, by William A. Lucy; Biological Changes in the Spleen of the Frog, by Alice L. Gaule; Histogenesis of the Retina in Amblystoma and Necturus, by F. Mall; and Homology of the Centrosome, by S. Watasé. All these articles are suitably illustrated in the plates.

No. 2 of Vol. I of the *Contributions to the Botanical Laboratory of the University of Pennsylvania* is devoted to a Botanical and Economic Study of Maize, by John W. Harshberger. The botanical account, under which are included gross anatomy, histology, bibliography, synonyms, and name, is followed by a discussion of the origin of maize, with evidences afforded by meteorology, botany, archæology, ethnology, philology, and history; after which its geographical distribution, chemistry, agriculture, physiology, utility, and future are considered.

The paper of Mr. *William Trelease*, of the Missouri Botanic Garden, St. Louis, on *The Sugar Maples, with a Winter Synopsis of all North American Maples*, is devoted, first, to the identification and description of the varieties which are known in different parts of

the country as sugar maples; and, second, to a detailed botanical description of the winter appearance of the several species of maple; giving the characters of bark, color, etc., of twigs, buds, and other marks apparent in winter by which the species may be distinguished at that season. The leaves, seeding, and buds of several of the varieties are further illustrated in engravings.

The report of *The Peabody Museum of American Archæology and Ethnology* represents that during the absence of Curator Putnam as chief of the Department of Ethnology at the Chicago Exposition the work of the museum was continued without interruption. Much progress was made in the arrangement of collections in the new halls, one of which is devoted to the objects gathered by the several expeditions to Yucatan and Honduras during the past five years. The expedition of 1892–'93 was prematurely terminated on account of the death of its chief, Mr. Owens, and the placing of another expedition is delayed. A memoir on Indian Music, by Miss Fletcher, published as No. 5 of the museum papers, is the result of twelve years' study, and contains the words and music of nearly one hundred songs of war, friendship, love, and ceremonial, with a scientific study of the structure of Indian music. The museum's exhibit at Chicago was of the most satisfactory character.

The Chemical Publishing Company, Easton, Pa., are publishing in monthly numbers, to be of 48 pages each, *Principles and Practice of Agricultural Analysis*, by Dr. *H. W. Wiley*. The work will be issued in two volumes, of which the first, in ten numbers, comprising nearly five hundred pages, will contain a description of the origin of soil and fertilizers, and the method of their examination; and the second will be devoted to the best approved methods of analyzing agricultural products. An attempt will be made to condense all the material into twenty-four numbers; but if this can not be done, a third volume will be published. The price of the work will be 25 cents a number. Publication began in January, 1894.

Naturæ Novitates—Natural History News—is the name of a semimonthly publication giving a bibliographical list of current literature of all nations in natural history and the exact sciences, published by R. Friedlander & Son, Berlin, N. W., Carlstrasse, 11, at 25 cents a number. All titles entered are numbered consecutively from 1 up.

A *Laboratory Manual* of 90 pages, consisting of a course of experiments in organic chemistry, by *W. R. Orndorff*, assistant Professor of Chemistry at Cornell University (D. C. Heath & Co., 40 cents), is arranged to accompany Remsen's Organic Chemistry. It contains a commendatory preface by Remsen. Each experiment is followed by a series of questions and a blank sheet for notes.

Under the simple title *Guide to the Study of Common Plants*, Prof. *Volney M. Spalding* has published a thoroughly practical manual of laboratory study in botany (Heath, 85 cents). The author supports fully and freely the modern doctrine that a knowledge of things should be gained through studying the things themselves rather than what some one has written about them. The book is adapted to classes in high schools and similar institutions. The pupils are assumed to have parts of plants before them at every lesson, and the exercises consist of directions for examining this material so as to learn what it has to teach. Seven chapters are given to the several principal parts of flowering plants, after which the chief botanical families represented among common plants are studied in succession. Full directions for study, lists of material, apparatus, and reference books are given, and there is some practical counsel for student and for teacher.

The plan of the recently issued *Treatise on Hydrostatics*, by Prof. *Alfred G. Greenhill*, of Woolwich (Macmillan, $1.90), is to develop the subject from the outset by means of illustrations of existing problems. In this way the author hopes that the student will acquire a real working knowledge of the subject, while at the same time the book will prove useful to the practical engineer. Particular attention has been given to the applications of the subject in naval architecture. With regard to details it may be mentioned that the condensed notation of units proposed by M. Hospitalier at the International Congress of Electricians of 1891 has been employed, and in the mathematical processes a free use has been made of the symbols and operations of the calculus. In support of the latter policy the author quotes the saying

that "it is easier to learn the differential calculus than to follow a demonstration which attempts to avoid its use." Pneumatics and hydraulics have been included as divisions of hydrostatics, and there is a chapter on the mechanical theory of heat.

Dr. *David G. Brinton* has reprinted from the Proceedings of the American Philosophical Society his account of *Nagualism*—a mystic cult that flourished in Mexico and Central America in the times of conquest and colonization (David McKay, Philadelphia, $1). The nagualists were of various tribes and languages, united in a powerful secret organization; they exercised necromantic powers and held occult doctrines. They were animated by an intense hatred of the Spanish explorers, and their one purpose was the destruction of the invaders and the annihilation of the government and religion introduced by them.

A recent bulletin of the United States National Museum is *A Monograph of the Bats of North America*, by *Harrison Allen*, M. D., being designed to take the place of the author's monograph on the same subject issued thirty years ago. The new work is made larger than the old by the addition of species and by elaboration of the descriptions. Thirty-eight plates, showing anatomical details, accompany the text.

A sketch of travel in California, by Rev. Dr. *Charles A. Stoddard*, has been published under the title *Beyond the Rockies* (Scribners, $1.50). Dr. Stoddard describes the fruit orchards, the wonderful climate, the big trees, the Yosemite Valley, the old missions, San Francisco and other Californian cities, etc., in a chatty and entertaining style. Incidents of travel are also mingled with the descriptions, and there are accounts of the scenery and stopping places in Texas, New Mexico, Arizona, Utah, and Colorado, which were passed through either in going or coming. The volume is copiously illustrated with photo-engravings of the places described.

A new translation of *The Social Contract*, of *Jean Jacques Rousseau*, with an introduction and notes by Prof. *Edward L. Walter*, has been issued (Putnam, $1.25). Students of political science will find in this book "the most striking statement of a theory destined to mold profoundly the history of nations," and will discover within it, also, "the weapons which are first sharpened and polished, and then directed against the whole framework of the modern state." The introduction reviews the political circumstances in which the treatise appeared, and the notes give historical facts concerning the persons and events referred to in the text, or references to books from which full information may be obtained.

In *David T. Day's* report on the *Mineral Resources of the United States* for 1892, the ninth of the series, the statistical tables of previous years are carried forward. Instead of chapters, the book is divided by mineral topics, which are so arranged as to bring kindred subjects together. The work is the result of a census conducted by the principal experts on each subject.

The *Report of the Chief of the Weather Bureau for 1891–'92* is the first volume of the meteorological data published by the office as now constituted, and continues the series heretofore published by the War Department. The necessity of crowding two years' work into one report has compelled condensation by the omission of the detailed hourly and twice daily observations; but this omission is partly supplied on the daily weather maps. Tables of monthly and annual normal pressure, temperature, and precipitation are given. A description of the instrumental equipment of observing stations by Prof. C. F. Marvin, and a report by Prof. Cleveland Abbe on the instrumental corrections, methods of reduction, and the probable resulting accuracy of the observations and the means, add much to the value of the volume. *Mark W. Harrington*, chief of the bureau.

The Commissioner of Labor of the United States publishes a special report on *Compulsory Insurance in Germany*, which has been prepared at his request by Mr. *John Graham Brooks*, after residing in Germany and making a careful and broad study of the subject and all the circumstances surrounding. The author was commissioned to collect all the official information available with reference to the system, and to ascertain in all legitimate ways its real workings, its effect upon labor and the workingman, and its general tendencies. Neither approving nor condemning the system, Mr. Brooks has given the

reasoning for and against it, and its results, taking up the steps which led to its institution and showing the phases attending its beginning and the experience under it after it was established. The report shows that the system aims at securing all that has been aimed at under various systems of charity, and that its ethical side was most potent in securing its establishment. It also appears that the compulsory insurance laws were not, as has been supposed, the result of a sudden conviction of an emergency to be met, but came directly through evolutionary processes covering long periods of time.

Besides the regular accounts of proceedings and progress, and the Report of the Secretary, the *Annual Reports of the Board of Regents of the Smithsonian Institution* for 1891 and 1892 contain in the general appendixes brief accounts of scientific discoveries in particular directions; occasional reports of the investigations made by collaborators of the institution; memoirs of a general character or on special topics, both original and selected; and other papers, as space permitted, supposed to be of use or value to the correspondence of the institution. The attention of the Board of Regents was largely given, during the two years covered by these reports, to the establishment of an Astrophysical Observatory. An accession of $200,000 to the endowment of the institution has been obtained through the bequest of Mr. Thomas G. Hodgkins, of Setauket, Long Island.

A map and tables of the *Average Elevation of the United States*, published by *Henry Gannett* in connection with the United States Geological Survey, give, in the map, by gradations of color, the elevations, at intervals rising from five hundred to three thousand feet, of the country and mountains, from the few spots below sea level up to "above ten thousand feet"; and, in the tables, the number of square miles, in each State and in the whole Union, at each grade of level, and the mean elevations of the several States.

The report of *Barton W. Evermann* and *William C. Kendall* on *The Fishes of Texas and the Rio Grande Basin* (United States Fish Commission) is designed to complete the studies published in a report made in 1892 preliminary to establishing a fish-cultural station in Texas. It is intended to include all the species, both salt and fresh water, which have been reported from the region named, so far as the authors have been able to learn. Geographically the paper is made to include, besides the State of Texas, all those parts of Colorado, New Mexico, and Mexico that belong to the hydrographic basin of the Rio Grande. The geographical distribution of the fishes is prominently considered. The report is illustrated by forty plates.

The Living Method for Learning how to Think in German proceeds on the assumption that if one tries to speak German while thinking in English, his conversation will consist largely of pauses, in efforts to recall the German expressions and to arrange them idiomatically; and that the only way to speak German is remembering what Germans say under the same or similar circumstances; not that one should live in Germany, but that he should live in German. The process is to associate the foreign phrases we have learned so perfectly with our actions that they will mentally suggest each other. The book furnishes the phrases for usual acts; then, whenever we do any of the acts, we should say, or think — in German—what we are doing. From this we go on, expanding our knowledge and practice, and making and learning new combinations. (*Charles F. Kroeh*, author and publisher, Hoboken, N. J.)

The Mechanics of Hoisting Machinery (Macmillan & Co., $3.75) is a translation made by *Karl P. Dahlstrom* from Prof. Herrmann's revised edition of Weisbach's great work on Engineering Mechanics—a work of which several volumes, treating of special subjects, are already familiar through translations. The present volume, however, has never heretofore appeared in English, although its value is generally recognized. The edition is intended as a text-book for technical schools and a guide for practical engineers. Within its purview are included levers and jacks; tackle and differential blocks; windlasses, winches, and lifts; hydraulic hoists, accumulators, and pneumatic hoists; hoisting machinery for mines; cranes and shears; excavators and dredges; and pile drivers.

The Peerless Cook Book, embracing more than one thousand recipes and practical suggestions to housekeepers, by Mrs. *T. J.*

Kirkpatrick, appears to be well adapted to the needs of working housekeepers. The recipes are plain, direct, and comprehensible, and for practicable dishes which may be in common use in the most modest households. They are also abundant in variety. Much pains is taken in the arrangement, and the articles are placed where they would come in a regular course dinner. Many of the recipes have been gathered from practical housekeepers; and of these not a few are original with the ladies and have never before been in print. The practical suggestions are excellent. (Mast, Crowell, and Kirkpatrick, Springfield, Ohio. Price, 50 cents).

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POPULAR MISCELLANY.

Social Factors of Crime.—Discussing the subject of criminology in one of the circulars of the Bureau of Education, Mr. Arthur MacDonald speaks of crime as seeming to be, to a certain extent, Nature's experiment on humanity. If a nerve of a normal organism is cut, the organs in which irregularities are produced are those which the nerve controls. In this way the office of a nerve in the normal state may be discovered. The criminal might be spoken of as the severed nerve of society, and the study of him as a practical way (though indirect) of studying normal man. The relation of criminology to society and to sociological questions is already intimate, and may in the future become closer. Just what crime is at present depends more upon time, location, race, country, nationality, and even the state in which one resides. But notwithstanding the extreme relativity of the idea of crime, there are some things in our social life that are questionable. A young girl of independence, but near poverty, tries to earn her own living at three dollars a week, and if, having natural desires for a few comforts and some taste for her personal appearance, she finally, through pressure, oversteps the bound, society, which permits this condition of things, immediately ostracises her. It borders on criminality that a widow works fifteen hours a day in a room in which she lives, making trousers at ten cents a pair, out of which she and her family must live, until they gradually run down toward death from want of sufficient nutrition, fresh air, and any comfort. It is criminally questionable to leave stoves in cars so that, if the passenger is not seriously injured but only hedged in, he will have the additional chance of burning to death. It has been a general truth, and in some cases is one still, that a certain number of persons must perish by fire before private individuals will furnish fire escapes to protect their own patrons. It is a fact that more than five thousand people are killed yearly in the United States at railroad grade crossings, most of whose lives could have been saved had the road or the railroad passed either one over the other. The excuse of the expense is pleaded for the lack of the improvements; or, practically, it is admitted that the extra money required to introduce them is of more consequence than the five thousand human lives. And yet, strange as it may seem, if a brutal murderer is to lose his life and there is the least doubt that the crime was premeditated, a large part of the community is often aroused into moral excitement or indignation, while the murdered innocent railroad passenger excites little more than a murmur. There is no subject on which the public conscience is more tender than the treatment of the criminal. Psychologically, the explanation of this is simple, for the public have been educated gradually to feel the suffering and misfortunes of the criminal—things it is easier to realize, since the thought is confined generally to one personality at a time. If the public could all be eyewitnesses to a few of our most brutal railroad accidents, the consciousness gained might be developed into conscientiousness in the division of their sympathies. The feeling spoken of is a sincere though sometimes morbid expression of unselfish humanitarianism.

The Arctic Sea.—In his address before the British Association on the Polar Basin, Mr. Henry Seebohm described the Arctic Sea, which lies at the bottom of the polar basin, as fringed with a belt of bare country, sometimes steep and rocky, descending in more or less abrupt cliffs and piles of precipices to the sea, but more often sloping gently down in mud banks and sand hills. These latter represent the accumulated spoils of countless ages of annual floods, which tear up the banks of the rivers and deposit shoals of detritus at their mouths, compelling them to make deltas in their efforts to force a passage to the sea. In Norway this belt of bare country is called the Fjeld, in Russia it

is known as the Tundra, and in America its technical name is the Barren Grounds. In the language of science it is the country beyond the limit of forest growth. In exposed situations, especially in the higher latitudes, the tundra does really merit its American name of barren ground, being little else than gravel beds interspersed with bare patches of peat or clay, and with scarcely a rush or a sedge to break the monotony. In Siberia, at least, this is very exceptional. By far the greater part of the tundra, both east and west of the Ural Mountains, is a gently undulating plain, full of lakes, rivers, swamps, and bogs. The lakes are diversified with patches of green water plants, among which ducks and swans float and dive; the little rivers flow between banks of rush and sedge; the swamps are masses of tall rushes and sedges of various species, where phalaropes and ruffs breed, and the bogs are brilliant with the white, fluffy seeds of the cotton grass. The groundwork of all this variegated scenery is more beautiful and varied still—lichens and moss of almost every conceivable color, from the cream-colored reindeer moss to the scarlet-cupped trumpet moss, interspersed with a brilliant Alpine flora, gentians, anemones, saxifrages, and hundreds of plants, each a picture in itself; the tall aconites, both the blue and yellow species; the beautiful cloudberry, with its gay white blossom and amber fruit; the fragrant *Ledum palustre*, and the delicate pink *Andromeda polifolia*. In the sheltered valleys and deep watercourses a few stunted birches, and sometimes large patches of willow scrub, survive the long, severe winter, and serve as cover for willow grouse or ptarmigan. The Lapland bunting and red-throated pipit are everywhere to be seen, and certain favored places are the breeding grounds of snipe, plover, and sandpipers of many species. So far from meriting the name of barren ground, the tundra is for the most part a veritable paradise in summer. But it has one almost fatal drawback—it swarms with millions of mosquitoes. The tundra melts away insensibly into the forest, but isolated trees are rare, and in Siberia there is an absence of young wood on the confines of the tundra. The limit of forest growth appears to be retiring southward, if we may judge from the number of dead and dying stumps; but this may be a temporary or local variation caused by exceptionally severe winters.

Cayuga Lake as a Rock Basin.—In a paper entitled Lake Cayuga as a Rock Basin, Ralph S. Tarr, after describing the topography of the region and giving a summary of the opinions previously held, attempts to prove that Cayuga, and presumably other of the lakes called Finger Lakes, is situated in a rock basin, with a maximum depth of approximately four hundred and thirty-five feet. The nature of the proof is that the preglacial tributaries to this valley are found to be rock-incased, and that their lowest points are above the present lake surface. The paper presents also a brief discussion of the reason why a rock basin may be supposed to have been constructed with comparative ease in this region, and a rhythm of glacial erosion and deposition is suggested. The course of the preglacial Cayuga River is found to be northward, probably tributary to a river which drained at least one of the Great Lakes—Ontario. As the tributaries of Cayuga River prove the rock-basin origin of Cayuga, so also the Cayuga River tributary of the Ontario stream indicates that Lake Ontario is likewise a rock basin.

The Expert Witness.—As one of the embarrassing features in the situation of the "scientific expert" witness, Prof. Charles F. Himes mentions that he is legally a witness, an ordinary witness, but practically endowed with extraordinary functions and loaded with extraordinary responsibilities—sometimes, perhaps, with extraordinary and even absurd expectations. As a witness he is under the same liabilities, rules, and restrictions as other witnesses, yet, by the circumstances under which he is called, he "exhibits the character of a very willing witness, of a well-paid witness, combined with a great deal of the advocate. Now, he can not be held responsible for this position, but the system of jurisprudence, which not simply permits it, which has not simply taken him but has forced him in, and which, apparently cognizant of all, seems only able to originate complaints rather than to provide a different character for him; for there seems, indeed, in many of the adverse criti-

cisms of experts, to be only a confession of weakness rather than a disposition earnestly to consider the whole question with a view to the radical remedy of the evils. The human nature of the judge is recognized and provided against. . . . The jury is selected so as to be free from bias, and is protected as well. Other witnesses are not expected to take the part the scientific expert is almost compelled to take. In fact, if deliberately planned, there could hardly be a network of conditions devised calculated to produce so many of the evils of scientific expert testimony complained of or to cloud this testimony of highest intrinsic value, having the highest degree of certainty, and in a field altogether its own." These witnesses are sometimes supposed to be selected on account of their ability to express a favorable opinion, when they are flippantly styled "adroit advocates of the theory of the party calling them"; but in how many cases, Prof. Himes asks, "does favorable opinion—or bias, if you please—precede the call of an expert rather than depend upon the call?" And the still more pertinent question, "How many experts are not in the particular case because their opinions are not wanted by the party who consulted them?"

Death Valley, California.—The principal features of popular interest in Death Valley, California, as described in Prof. Harrington's Notes on its Climate and Meteorology, are its excessive heat and dryness. The temperature rises occasionally in the shade to 122°, rarely falls at any time in the hot months below 70°, and averages 94°. It is not only hot in the summer, but consistently hot, and the heat is increased by occasional hot blasts from the desert to the south. The air is not stagnant, but in unusually active motion. Gales of a few hours' duration are very common, and sometimes produce sand whirls and sand storms. Rains may fall frequently in the mountains and occasionally in the valley. Clouds are by no means lacking, and water can probably always be found in the soil at the depth of a few feet, yet the heat and wind together keep the surface very dry and the relative humidity low. Animal and plant forms are comparatively few, and the former are usually nocturnal to avoid the heat. Both heat and aridity are increased by the character of the valley. It is narrow and deep, apparently the bed of an old sea, inclosed by high and dry mountains. The white and shifting sands become much heated under the noonday sun; the rest of the surface is in part salt and alkali, in part probably wash from the mountains, and in part a loose, spongy earth, over which it is difficult to move. With the exception of a few springs, the water is bitter and unwholesome. The meteorological features of interest lie, for the most part, in those modifications of diurnal changes which are due to the topography. The range of temperature is unusually great. The hourly progress of the wind shows enormous changes in speed, in direction, and in temperature. The diurnal change in the barometer is the most characteristic of the form found in continental valleys. It is of the purest single maximum type and has the largest amplitude known. With these features go sharp thunderstorms, limited to certain hours of the day, and daily gales and hot blasts. It is also noteworthy that the absolute humidity here is fairly constant, and is that belonging to that part of the world. The air in the valley is part of the general aërial ocean, and this shows no sharp contrasts in its moisture contents, except when wind prevails across a mountain ridge. Here the prevailing winds are up and down the valley, and its relative aridity is due to its higher temperature. The winter climate is believed to be cool and salubrious, with an inch or two of rain.

The Vacuum Jacket and Liquid Oxygen.—Prof. Dewar protects his liquefied gases, in order to keep them in that state, from the heat of convection, by inclosing them in a vacuum jacket; and from the heat of radiation by silvering the surface of the containing vessel. He is thus able to keep liquid air for thirty or forty hours. The vacuum used contains a little mercury vapor, which, though present in very minute quantities, can be condensed into a bright mirror by cooling the outside surface of the vessel with liquid air. Among the experiments made in one of Prof. Dewar's lectures to illustrate the properties of liquid oxygen, alcohol, which freezes at −120°, solidified when dropped into it, and in that state would not take fire. So-

dium burns with intense brilliancy in gaseous oxygen, but in liquid oxygen would not burn at all, the very low temperature (—180°) hindering chemical action. Liquid oxygen has an electrical resistance five or six times greater than that of the gas, which itself is strongly magnetic. Put under the poles of an electro-magnet, the liquid leaped up to them when the current was passed, and a little piece of cotton wool saturated with it was strongly attracted. Ordinary air from the room was liquefied in the presence of the audience. A small tube of liquid oxygen, placed in a vessel of air, was put under the air pump, and in a short time liquid air began to condense on its surface. Although the nitrogen and oxygen of the atmosphere are liquefied simultaneously, yet nitrogen, being the more volatile, boils off first, and leaves liquid oxygen behind. This can be proved by holding a glowing taper over a vessel of liquid air; it does not burst into flame until about four fifths of the contents have evaporated. Liquid air is magnetic, but more feebly so than liquid oxygen. It is also blue, and the absorption bands in its spectrum are less dark.

Bohemian Graphite.—Natural graphite occurs usually in masses and veins in the oldest rocks, like granite, gneiss, mica schist, and porphyry. At Schwarzbach, in Bohemia, it is found in irregular masses in the gneiss, apparently brought there after the formation of the rock, and having been substituted for the mica, of which it in some places takes the foliated texture. Schwarzbach is situated on a grassy plain among the wild mountains of southern Bohemia, in the district of Kruman. The mines and surrounding country belong to the immense domains of the Prince of Schwarzenberg. The mines employ eight hundred workmen, and produce from six thousand to ten thousand tons a year. The graphite is mined in shafts sunk one hundred metres or more beneath the surface of the ground. Being impregnated with water, it is easily broken into small blocks by the pick. It is sorted by the miner into first and second choice—*prima* and *raffinade*. These piles are again sorted, a different process being observed with either kind. The *prima*, which is designed for pencil-making, is sorted by hand, and all impurities and hard particles are removed from it. The *raffinade* is passed under millstones where a current of water passing carries off all the richest parts, and, giving up the sand and pyrites in a series of pans provided for them, carries the purified graphite into another series of pans. If pyrite is present in considerable proportions, it is burned out by passing the matter in gratings over flame.

The Waganda.—Describing Uganda in the British Association, Captain Williams said that whatever the merits of the country, the people were worth keeping, for they were a wonderful race. The missionaries had done great good, notwithstanding the conflict of religions. The men were fine, well built, and athletic, and the women were active and intelligent. They were not universally black—indeed, in Central Africa there was a considerable variety of shades. They had a strange theory of transmigration of souls, which prevented the people from utilizing the food supply that lay before them. The people were simply dressed; the women were not allowed to wear white cloth, while the men wore white if they could get it. They wore "bark cloth," which was stretched out on pegs to the right length. The Waganda were polygamists, each man having seven wives. The women were very happy, and did the hoeing and other agricultural work, while the men built the houses and carried the food. A man as a rule bought his wives. In one case he met a man who had bought a wife for four cows. He had paid two of the cows and then the lady was eaten by a leopard. He thought it was very hard lines that he should be compelled to pay the remaining cows. The houses were, as a rule, mere slight, temporary structures, but the house in which the late King Mtesa was buried was a wonderful structure with twenty feet or more of thickness of thatch. The churches—both Catholic and Protestant—were extremely fine, but the former had unfortunately been burned. The cruelties of the people had been much exaggerated, and were not comparable to the atrocities which were once committed. In former days a king had all the people killed who passed along a certain road from morning to night, and a man's life was almost worthless. The

love of music—especially the drum and the pipe and a sort of rude violin—was characteristic of the people. There was abundance of big game and the Waganda were capital hunters, and their method of hunting was quaint and original in the extreme. A huge crowd, armed with stout sticks, beat down the high grass level and tracked the leopard or lion to his lair, and, getting him inclosed within a space equal to a good-sized room, literally beat the beast to death, and it rarely happened that anybody was much hurt.

The Gothenburg System.—In summarizing his conclusions as to the advantages and disadvantages of the Gothenburg or company monopoly system of liquor traffic in operation in Sweden and Norway, Dr. E. R. L. Gould insists that the system was not originated with the idea of stopping the consumption of liquors, but to combat drunkenness and reduce the evils consequent upon inordinate indulgence in alcoholic drinks. It is founded, too, upon the principle that, since, taking human nature and practices as we find them, it is impossible immediately to eradicate the evil completely, it is better to regulate it through the higher rather than the lower elements of the community. Its strength lies along the line of preventive rather than of reformatory elements. Among the advantages named is, first, the complete divorcing of the liquor traffic from politics. Further, the company monopoly has been so administered that a general reduction of the number of licenses has been brought about everywhere, and, consequently, a lessening of the temptation to drink. "It would be a very strange condition of affairs indeed, in any matter of this kind, if, when the element of private gain was entirely eliminated, a resulting improvement did not take place." A series of effective checks is imposed against a breach of trust, supposing there may exist an inclination to commit it. The companies have, in some measure, gone beyond the legal requirements in the line of general interest, particularly in raising the age of minority from fifteen, where the law puts it, to eighteen, as regards selling drink to young persons, and also in insisting immediately on cash payments. They have gradually raised the price of drinks and reduced their strength. In Norway the saloons are closed on Sundays and at those times of day when the workingman is most tempted to drink. All men employed are paid fair fixed salaries, and there is no temptation to push sales. All taxes are paid under the company system without shuffling. The cause of temperance has been assisted financially and otherwise. The profits on sales of drink are expended for the relief of society. No community which has tried the system has afterward abandoned it. The measure is supported by the temperance party, though many of them would prefer prohibition. The disadvantages are laid mostly to defects in existing law, rather than to faults inherent in the system itself. The monopoly does not extend far enough, but should cover fermented drinks; the limit for retail sales is not fixed high enough; the sale of liquors is often connected with general business, from which it should be separated; a monopoly of production by the state does not exist; the question of profits is still too conspicuous; and, from the temperance view of the case, it is feared that the upper classes of society do not wish to go further than the Gothenburg system.

Volcanic Rocks in Eastern North America.—Mr. George H. Williams has insisted on the presence, in the oldest geological formations, of igneous rocks, disguised, perhaps, under a foliated structure, and has dwelt upon the methods by which their origin may be established. The object of a paper by him on The Distribution of Ancient Volcanic Rocks along the Eastern Border of North America is to show that igneous, and volcanic rocks as well, are widely distributed through the crystalline belt of eastern North America, and to direct attention to them as offering a new and promising field for work in crystalline geology. His review of the field leads him to the conclusion that this class of material is abundant. It has been identified from Newfoundland to Georgia. For many areas the evidence of surface or volcanic origin is conclusive, while in many others it is as yet only probable. The areas of these ancient volcanic rocks now known fall roughly in two parallel belts; of these, the eastern embraces the exposures of Newfoundland, Cape Breton, Nova Scotia, the

Bay of Fundy, coast of Maine, Boston basin, and the central Carolinas; while the western belt crosses the Eastern Townships and follows the Blue Ridge through southern Pennsylvania, Maryland, Virginia, and North Carolina, to Georgia. Further and fuller studies of the subject are desired by the author, who remarks that the identification of truly volcanic rocks in highly or partly crystalline terrains possesses far more than a petrographical significance, since, by fixing what was the surface at the time of their formation, they furnish a certain datum for tracing out the sequence of later geographic changes and geological development.

A "Copper Age."—An account of the discoveries made at Tel-el-Hesi, the site of the ancient city of Lachish, in Palestine, gave rise, in the British Association, to a discussion concerning a probable copper age. The very high mound contains the ruins of several towns, built each (except the lowest) on the ruined remains of its predecessor. The uppermost was an Israelitish town, and was very probably the remains of the Lachish which was besieged and destroyed by Sennacherib in the time of Hezekiah. Throughout the mound, from the bottom to the top, were found flint and metallic implements. Among them was a thick chisel made of copper, which had been hardened by mixture with red oxide of copper, from which it received a red appearance. Toward the top of the mound were bronze arrowheads, which probably dated back to between 1400 and 1500 years B. C. In the ascent of the mound a change was observed from copper to bronze and from bronze to iron, which was very common in the Israelitish town. Lead was found in the form of a thick wire, very pure. A silver bangle contained ninety per cent of silver, considerable copper, and an appreciable quantity of gold. Sir John Evans spoke of the evidences of a copper age preceding a bronze age, seen in North America, Ireland, Hungary, and other countries. Dr. Hildebrand said that several implements of pure copper had been found in Sweden. Prof. Boyd Dawkins thought the evidence from North America showed that the copper age was practically a side of the neolithic age. Prof. A. H. Sayce spoke of the absence of words for tin in the Egyptian and Assyrian languages, although the metal was known in Egypt as far back as the eighteenth dynasty, and although there are words in both languages for gold, silver, iron, copper, bronze, lead, and possibly metallic antimony. The word for iron in Egyptian meant metal from heaven, and in Assyrian, heavenly metal. This would indicate that their iron was meteoric.

Feats of Diving Birds.—Naval architects are credited with saying that the highest speed in navigation could be obtained by submarine boats. The principle is illustrated in the diving birds, which are capable of shooting through the water with amazing velocity. While these birds live by catching fish in deep water far below the surface, they present many differences in outer appearance. In the collection at the London Zoölogical Gardens are black-footed penguins, guillemots, "darters," a puffin, and a cormorant. The penguin can not fly in the air, can not walk, but hops as if its feet were tied together; and can not swim; and can only with any grace fly under water. When the keeper of their quarters appears to feed the birds, they each behave in their characteristic way. The fish thrown into the water, the penguins instantly plunge beneath, when an astonishing change takes place, thus described by a writer in the Spectator: "The slow, ungainly bird is transformed into a swift and beautiful creature, beaded with globules of quicksilver, where the air clings to the close feathers, and *flying* through the clear and waveless depths with arrowy speed and powers of turning far greater than in any known form of aërial flight. The rapid and steady strokes of the wings are exactly similar to those of the air birds, while the feet float straight out, level with its body, unused for propulsion, or even as rudders, and as little needed in its progress as those of a wild duck when on the wing. The twists and turns necessary to follow the active little fish are made wholly by the strokes of one wing and the cessation of movement in the other; and the fish are chased, caught, and swallowed without the slightest relaxation of speed, in a submarine flight which is quite as rapid as that of most birds which take their prey in midair." The head and shoulders may be

brought above the surface for a second, and then disappear; but any attempt to remain on the surface leads to ludicrous splashing and confusion, for the submarine bird can not float. The movements of the cormorant are quite different. It does not plunge headlong, but "launches itself on the surface, and then 'ducks' like a grebe. Its wings are not used as propellers, but trail unresistingly level with its body, and the speed at which it courses through the water is wholly due to the swimming powers of its large and ugly webbed feet. These are set quite at the end of the body, and work incessantly like a treadle, or the floats of a stern-wheel steamer. Yet the conditions of submarine motion are so favorable that the speed of the bird below the surface is three or four times greater than that gained by equally rapid movements of the feet when it has risen and is swimming on the top." The "darters"—divers of the African and American lakes, compared to the survival of some ancient lizard—dive and swim much like the cormorant, except that the bird keeps its neck drawn back in the form of a flattened S when in pursuit of the fish. "Once within striking distance, the sharp bill is shot out as if from a catapult, and the fish is spiked through and carried to the surface. This ascent is made after each single capture. Sometimes the bird has great difficulty in disentangling the pierced fish from the spearlike beak, and its companion adroitly relieves it of the struggling victim and swallows the prize."

An Ominous Forecast.—A dismal future is foreseen by M. Leroy Beaulieu, with two new and exhaustive processes going on in Europe, and, we might add, demanded by large classes in America. They are the rapid increase of state and communal expenditure, which in France, Germany, Italy, and Great Britain is augmenting by leaps and bounds, mainly for unproductive outlay on defense; and the other is the still more rapid increase of demands for grants-in-aid to institutions intended to benefit the poorer classes. More education, more guarantees, more "civilization" of all kinds—there is no end to the proposals. Every European state except Austria-Hungary has already a large deficit; besides which the communal expenditure is advancing incessantly in France, and in a less degree in Germany, while in Italy it is menacing the foundations of society. It is impossible that the twofold expenditure, on the means of killing and on the means of philanthropy, should go on without new taxation, and every tax diminishes the fund available for the payment of labor. No prospect is seen of these two depleting processes coming speedily to an end. Formerly they were checked by the rage of the taxpaying classes; but universal suffrage disregards that, and may go on taxing until its mood changes, or its own sources of supply begin visibly to fail. The demands partly urged by actual necessities, and otherwise being in the line of modern philanthropy, "which desires improvement in everything except manly independence," and further promoted by the fact that reasonable wants increase more rapidly than the means of satisfying them, are likely to go on advancing. In view of these circumstances, men of M. Leroy Beaulieu's school think that a time of grave economic distress, producing great social and political changes, is at hand for western Europe.

NOTES.

The plague reported as prevailing in China is described by a correspondent of the British Medical Journal as presenting all the symptoms of the true bubonic pest which devastated Europe in the middle ages. Although extinct in Europe, this pest has never ceased to prevail in China from time to time, and has also spread from there to Persia and Asiatic Russia. The present outbreak is characterized by intense symptoms corresponding to those of typhus, and by the bubonic boils characteristic of the disease. Europeans are not affected by it, except the soldiers who come directly in contact with it in disinfecting work. It is extremely contagious from person to person, but the danger from aërial infection is slight.

In the "Crump Burial Cave," Blount County, Ala., which was discovered in 1840, were several coffins of black and white walnut, "dug out" of logs, twelve or fifteen human skulls, and other human bones scattered about, masses of galena, grooved like the aboriginal stone axes or mauls, as if for use as war clubs, and other more usual implements. Near this cave Mr. Frank Burns has since found an Indian ladder that had been used to climb up to a "rock house," a large, roomy, dry place under overhanging

cliffs of stone, which was also probably employed for burial purposes. The ladder was a trunk of a cedar tree, having seven or eight steps, eighteen or nineteen inches apart, made by cutting a scarf into the tree. There are many such houses, Mr. Burns says, in the coal measures, and they were used by the aborigines as dwelling or burial places.

A blue mineral discovered near Silver City, New Mexico, and supposed to be ultramarine, occurs in irregular veins and streaks in the lime carrying the silver ore which is mined at Chloride Flat. The specimens procured by Mr. G. P. Merrill for the United States Museum exhibit the earthy blue substance which on casual inspection resembles ultramarine, associated with calcite and other substances; the analyses show, according to Mr. R. L. Packard, a chemical resemblance to talc, although the physical properties of the two minerals are different.

A company engaged in the construction of an electric railway on the Jungfrau proposes to devote twenty thousand dollars to the erection of a geophysical observatory at an altitude of about fifteen thousand feet, and to apply one thousand dollars a year for its maintenance.

The Jakuns, or aboriginals, of Johore (Malacca) live in small communities on the banks of jungle streams, subsisting miserably on fruits, tapioca, roots, and small fish and reptiles. They seldom remain long in the same spot, but wander from place to place, living under scanty leaf shelters built on rickety poles at a considerable height from the ground. It is not uncommon to find a dozen men, women, and children, in company with a tame monkey or two, a few dogs and cats, innumerable fowls, and perhaps a tame hornbill, living in perfect harmony under the same miserable shelter. These aborigines are all very expert fishermen, using chiefly the three-pronged spear.

The National Home Reading Union of England has for four years followed the practice of taking its students every summer into the fields, to the places which best illustrate the subjects on which they are at work. Thus, this year, while the general meetings were held at Buxton, special meetings were held at Salisbury, for the study of the monuments, abundant in the district, illustrating the archæology, art, and history of early England—"from Stonehenge to Salisbury Cathedral." Special excursions were given for botany, geology, etc., and conferences on social and educational subjects.

Dr. D. L. W. Robinson, President of the South Dakota State Board of Health, is convinced from experience in practice in that region of great climatic variation and pressure that a close relationship exists between weather changes and health and disease. Yet he fails to identify this relationship specifically with either barometric changes or low temperature, and suggests that it may be connected with electrical conditions as the principal factor.

According to the Bulletin of the American Geographical Society, the recent study of the observations on mountain summits in the neighborhood of Mount St. Elias shows that Mount Logan is the loftiest peak in North America, its height being 19,500 feet—1,200 feet greater than that of Orizaba, and 1,500 feet more than that of Mount St. Elias.

OBITUARY NOTES.

The death is announced at Geneva, Switzerland, of the eminent chemist, J. C. de Marignac, formerly professor in the University of Geneva. He retired from his professorship in 1878, but continued his studies in a laboratory, which he fitted up at home, till the end of his life. He was well known for his researches on ozone and on chlorine, silver, potassium, sulphuric acid, and other substances in the domain of mineral chemistry. He was a correspondent of the Institute of France, and received the gold medal of the Royal Society in 1886. He was modest to excess and led a retired life of labor, the fruits of which made his name known throughout the world.

The death is announced of Prof. Adolph Leipner, Professor of Botany in University College, Bristol, England. He had been honorary secretary from its beginning in 1862, and was at the time of his death President of the Bristol Naturalists' Society.

Prof. August Kundt, the eminent physicist, died May 21st at his country place near Lubeck, fifty-four years of age. He was born at Schwerin in 1839 and was graduated from the University of Berlin in 1864, presenting as his thesis an investigation on the depolarization of light. He became a privatdocent in the University of Berlin in 1867, and was afterward a professor in the Polytechnic Institution at Zurich, at Würzburg, in the University of Strasburg, in the organization of which he had an important part, and in the Berlin Physical Institute, where he was also director. His first investigations were in acoustics and were gradually extended to embrace a large range of subjects. Perhaps the most important of them were in optics and magneto-optics.

M. A. Derbès, one of the pioneers in the study of the life history of the algæ, has recently died in Marseilles, France. In conjunction with M. Solier he was the author of a work on Zoöspores of the Algæ and the Antharides of the Cryptogams, published in 1847, which was rich with new facts and formed the basis of all later observations on the same subject.

ASAPH HALL.

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THE FOOTBALL SITUATION.

By EUGENE LAMB RICHARDS,
PROFESSOR OF MATHEMATICS IN YALE UNIVERSITY.

I WRITE not as an expert, but rather as an intelligent sympathizer. I have been for twenty-five years an instructor in Yale College, and believe thoroughly in its traditions of work and scholarship. From my youth up having been fond of athletic exercises, and as a student always ready to participate in them, I can write of them understandingly. I have known personally all the captains of the Yale football teams for the past twelve years, most of them intimately. With one exception they have all been my pupils. One of them was a member of my own family. Having exceptional knowledge of the subject, which the possession of these opportunities grants to but few men, I deem it a duty to put in permanent form the results of my observations. I have already done this with reference to the subject of athletics in general.* In this article I wish to confine my attention to the game of football.

I hope to prove that with all its faults it is one of the best forms of athletic sport which can be invented; that by no other game or exercise practiced by young men are the players themselves so much benefited as by football; that the colleges ought to be as much interested in keeping it up as are the most enthusiastic football players themselves; that the public, who have boys to educate, ought to acquaint themselves with the subject. Watching the games when possible, they ought not to allow themselves to be beguiled into condemnation of the sport by sen-

* The Popular Science Monthly, March and February, 1884.

sational writers, who inveigh against it either because they know nothing of it, or because they have determined to know nothing of it, since it does not square with their "historic and traditional idea" of things suitable to a college. Lastly, I wish to suggest lines along which measures for the improvement of the game should be taken, and also to advocate some measures for the better supervision of the sport.

It will surprise many good people, who have been accustomed to hear such an epithet as "brutal" applied to the game of football, that I should claim for it as the first point of superiority over other college athletic sports that it is eminently an intellectual game. A game of football between contestants evenly matched in other respects is won by the superior mental work of the winning team as embodied in the generalship of the captain and the thoughtful work of his men. The game is not simply a struggle for mastery of one body of strong men over another, but it is a contest for supremacy, in which supremacy is gained not by physical strength alone, but by this strength rightly directed by mind.

In the first place, the rules of the game must be observed by every player. He must conform his play to them. He must have them thoroughly in mind, in order to know what he can do, as well as to avoid what he is not permitted to do. These rules are very numerous—more numerous, I believe, than the rules of any other college sport, and cover a wider sphere of action. The interpretation and application of them in every moment of play call for no ordinary quickness of mind in a successful player.

Though each man has a special line of play belonging to his position on a team, yet his play is so related to the plays of the rest of the team that he can not act without regard to the other players. It is eminently a game of combinations. Individual play is important, but team play is more important. The signals of the captain must be heeded by all the players, even if they seem to be given for only two or three men. Through weeks of preparation these signals have to be studied, to be memorized, to be practiced as thoroughly and faithfully by the men as the laws of any science by successful scholars.

The only other college game which is to be compared with it in respect of team play is the game of baseball. Yet in this game the players have fixed positions. Though the men in these positions play in combination with each other, they are remote from one another, and do not at any time join together to make a particular play effective, as the players of a football team move to a common goal. Though team play is important, it is not as important as in football, while individual play, as, for instance, that of pitcher or catcher, is more important. In rowing, the work,

though requiring skill and severe training, is largely mechanical. In track athletics the individual is everything.

That the game has had attractions for intellectual men in the past is shown by the fact that the average scholarship of men on the football teams has of late years been higher than that of men in the other athletic organizations. In the years 1879 to 1888 the average standing of men not on athletic organizations was on a scale of 4, 2·69; for members of the university boat crew the average was 2·52; for members of the baseball nine it was 2·41; for members of the football team it was 2·68. Track athletics were not in existence as an organization through the whole decade, but for the few years when there was a university team the average was 2·66. In the previous decade, 1869 to 1878, it is only fair to add that the average of the football men was slightly below that of the other athletes, it being 2·51 to their 2·56. I can only account for the fact of the rise of the average in the second decade by the change in the numbers of the team from twenty to eleven—a change giving opportunity for more skill, thus rendering the play more attractive to men of mind. Notwithstanding the present style of mass play, which puts a premium on physical strength and weight, it was a surprise to me to find that the average scholarship of the sixteen men from the academic department, including players and substitutes, was higher than the average of any class which ever graduated. I can not believe, however, that the high scholarship of football players will always prevail, unless the style of the game be changed to one which admits of more open play.*

Another advantage of the game is that the practice of it engages a large number of players. A regular team has two more men than the baseball nine, and three more than the crew of eight men. The substitutes, having a systematic training, are more numerous than the substitutes for either baseball or for the crew. Track athletics only can be compared with it in the numbers brought into it. For a short period of the year this latter sport may exercise more men, but taking into consideration the various class teams of football, and especially the team of the freshmen class with substitutes, it is doubtful if even the numbers of those engaging in track athletics exceed the numbers engaging in football.

Of the benefits accruing to the players the physical benefits are the least noteworthy. Yet the play brings into activity almost every muscle of the body. The legs, the arms, and the trunk are all used. No part of the muscular system is developed abnor-

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* The style of the game will be changed by the adoption of the new rules, lately recommended by the committee of graduates.

mally. In addition to the opportunity for this uniform development must be mentioned the care bestowed upon the players in the way of attention to injuries received. Not only is the best surgeon employed, but the best professional trainers and rubbers wait on the men to second the efforts of the doctor. To this continual watching of the men on the university teams is due not a little of the comparative immunity from serious injuries received of late years, notwithstanding the rough play in the field.

Another advantage to the players is derived from the great attention given to the diet, not only of the players of the regular team, but of any man who works faithfully as a substitute, or shows any promise of "making the team" at any time in a present or future season. Forty men are at times at the university training table, a number greatly in excess of those at the table of any other organization. The freshman team, too, with their substitutes, have their training table and their attendant coachers, rubbers, and trainers.

But great as are the benefits of the sport to the players in mind and body, they are not to be compared with its moral effects. If there is one virtue most to be desired in a manly character—without which, indeed, it ceases to be manly—that virtue is courage. And of the college sports there is not one which cultivates this manly virtue more than football. Neither is the courage required entirely physical. Indeed, the best players feel and see the danger which they brave. Conscious of injuries received, they often continue to face plays which may exaggerate their pains.

Then the need of self-control in the midst of strong excitement is another valuable lesson learned. Self-denial is taught in the voluntary abnegation of the delights of college, in the forsaking of indulgence in the luxuries of life. To training in courage, endurance, and self-control must be added the valuable lesson of obedience to authority. The discipline in this respect is as strict as the strictest military discipline. Men are required to obey captain and coach and to obey silently. This unquestioning, instant submission to word of command is not the least of the excellent lessons of a football season. It shows its effects in the whole college life and college world.

Strange as it may seem, a good claim can be made of a necessary connection between good character and good football in its best development. In everything requiring the best results the best success depends upon the best men. As there is no other college sport which so brings out the best virtues in a man, so there is no other college sport which is so dependent for its success upon good all-round men. Though this statement is measurably true for all amateur sports, it is emphatically true of football. It has been borne out by facts. The best teams in Yale have had not

only the best players, but the most successful teams have contained the most moral and religious men. In a class prayer-meeting I once heard a man, who was for two years a most valuable player (a captain one of those years), declare that the great success of the team the previous season was, in his opinion, due to the fact that "among the team and substitutes there were so many praying men." As it was with this man, so it has ever been with the successful captains as well as the successful coachers at Yale. They have been God-fearing men, upright in action and clean in speech.

With reference to the colleges, the good effects of the game of football which they produce in common with the other sports need only a passing mention. Among these may be instanced the *esprit de corps* to which they give rise, the healthy excitements necessary to young men which they furnish—excitements which, for many, replace and moderate, if they do not entirely drive out, the old excitements of gambling and drinking, gate-stealing, contests between town and gown, formerly so prevalent and so difficult to deal with on the part of the college authorities. But in addition to these and other benefits to the college world, football with its contests and training comes at a time of the year when it does the most good not only in the directions mentioned, but in two other ways. Boys who are just entering college and, who are for the first time in their careers freed from the restraints of school or home, it introduces to a new discipline, a discipline of their fellows, and to new ideals, which, if not the highest, are at least respectable and worthy of imitation. It brings many of them in contact with the best men in college, and saves not a few of them from wasting their idle hours in foolish and hurtful dissipation. Again, it absorbs the attention of all the college to such a degree as to divert the minds of many of those upper classmen who formerly thought they had a mission to perform in acquainting the new men with the submission required of them in their college home. The discipline of the sport coming at the time it does has almost entirely done away with that occupation. The freshmen have learned their lesson in a better way, under better instructors. The discipline of football has almost banished the discipline of hazing, or left it tame and without excuse for its existence.

To the public the sport is most valuable, especially for those who have boys to educate. The game has spread from the colleges to the schools. The discipline of play has helped the discipline of the study room. Indeed, it has supplemented it with a new education. It has furnished stronger bodies with better brains. It has given an antidote to excessive culture, which often enfeebles the body while it refines the mind. It has given

to the city youths a sport more fascinating with all its dangers and severe restraints than the temptations of city life. What this boon means in its effects upon the coming generations the coming time will show. It certainly is bringing forward a more virile race even in the cities. And the cities in the past have been the first points of decadence of a decaying civilization. As the census reports show, the population is flocking more and more to the cities, so that the growth of athletics began at a time when it was most needed. What President Eliot, in his late report, says of the effect of athletic sports at Harvard, applies with equal truth and force to athletics in all educational institutions—universities as well as schools—"namely, that there has been a decided improvement in the average health and strength of Harvard students during the past twenty-five years. The gain is visible in all sorts of students, among those who devote themselves to study as well as among those who give much time to sports." It was in the colleges that this increased attention to physical exercise was begun, and begun by the students themselves. The system extended to the schools. It has been the parent of most of the athletic clubs now in existence. It furnishes a healthy stimulus and recreation to thousands of young men who but for it would be wasting their strength in much more brutal and brutalizing excitements. It is not too much to say that it is the salvation of our youth. And just as the scholarship of our universities stimulates the intellectual life of these schools, so the athletic contests of the universities keep alive among the schoolboys a healthy admiration for a manly physique. This effect of the college sports has not been sufficiently noticed. It is worth all it costs. It could never have existed if it had not been for the publicity given to the college contests, and to football contests in particular. It has given order to play and introduced obedience to authority and the love of courage into every school in the land. It is not entirely because Yale and Harvard play football or baseball, row and train, that their students show a "decided improvement in their average health during the past twenty-five years," but also because their example has been followed by the schools, and consequently better developed young men are sent from the schools to the universities. The improvement is not confined to college students. It is noticeable in the young men of the whole land. It has produced another effect. The young women of the country have been induced to emulate the physical development of their brothers. They have not played all their rough games, it is true; still, it is undeniable that the greater attention to the physique of women is in some degree an effect of the visible good results of the better development of the men. And all the aids of physical development, such as gymnasiums,

athletic fields, and better playgrounds, have arisen to help on this good work.

As to the disadvantages of football, the sport is like everything else: it is subject to evils. The question is not whether there are evils attending the game, but whether the evils overbalance the good. I admit the evils, but I maintain that the evils have been exaggerated, and that they are not yet great enough to call for the abolition of the game.

Evil No. 1: Excessive time devoted to practice. This charge only applies to the last few weeks of preparation. The first weeks, two hours and a half for most of the players would be the maximum time. For the half-backs three hours would suffice for their maximum time. Part of this time, too, is consumed in going to and from the field or practice ground. Some of the players, more systematic than their fellows, do not consume even so much time. But in the last few weeks, varying in numbers according to the judgment of the captain and coaches of the year, more time is used, amounting, under the most exacting captain, to as many as five hours and a half a day for five weeks. I may add, however, that this exacting captain overdid the business, tired out his team, and suffered the humiliation of a defeat. The most successful captain whom I have known saved the time of his men all through the season, seldom giving them more than two hours' practice, and devoting only one week to hard practice. Five hours a day *is* too much time for a student to devote to any sport. So much time devoted to practice is not necessary for success. On the contrary, it interferes with success, so that this evil is bound to work its own cure. But, even granted that five and a half hours per day for five weeks were given to football practice, it does not follow that those are taken from study, or that, if the game of football were driven out of college, all the players would betake themselves to books. Some of them would give part of their time to study, but poor scholars of the team would still continue to be poor students. Indeed, it is my belief that they would be poorer scholars than before. When they are on the team the very necessity to economize their time compels these men to regular hours of work. When they cease to play football they waste their time. It has always been the result of my observation that though the good scholars of the team do better work in the winter and spring terms, the poor scholars at that time usually fall off in scholarship. But if football is a cause of poor scholarship, why is it that the cause is not uniform in its effects? If it were uniform in its effects all the players would be poor students. Yet the highest honor men are often members of teams. But it may be said that the introduction of football into college has affected the scholarship of the college in general unfavorably, even if it

has not so affected the scholarship of the players themselves. But the facts are against this theory. I took the trouble to go through the scholarship record of two decades—1869 to 1888—decades which witnessed the great development of athletics. For the first decade the average was 2·67 on a scale of 4; for the second decade it was 2·69. In the various sports the average scholarship of the football men was the only one which rose in the second decade higher than in the first, passing from 2·51 to 2·68.

Evil No. 2: Extravagance in expenditure of money earned. Charges of this kind have been made quite recklessly, not only against football but against athletics generally. Knowing that the football teams have earned a great deal of money and not knowing exactly how it is spent, enemies of the game have apparently assumed that it must have been spent extravagantly. None of this money goes to members of the team. It is all paid into the treasury of the Financial Union. The treasurer is a graduate. He pays out money according to the orders of the president of the Y. U. F. B. C., or of the manager of the team. The only persons, then, who could possibly be liable to the charges of wastefulness or extravagance are these three persons. The treasurer can be thrown out of consideration. He is simply an agent, and the writer can testify to the fact that the treasurer exercises a restraining influence. Moreover, as the Financial Union holds and disburses, through this treasurer, the moneys of the other athletic organizations, all the officers of that union (who are also officers of those athletic organizations) exercise a mutual oversight and watchfulness toward one another. This influence is felt for good by the two officers of the university football club as well as by all the others.

Undoubtedly every year much more money is spent than is necessary. Undoubtedly, also, much more money has been spent on football in the last few years than was spent in the first years of the existence of the game, and a judicious economy might have saved a good deal of this money. But it must be remembered that the age is extravagant; that more money is wasted in dress, in furniture, in all the vain show of living than was spent thirty years ago. It must also be borne in mind that in the infancy of the game only the fifteen or eleven members of the team were expected to have their unusual expenses paid out of the football treasury. Now there are a second team of regular substitutes, and many possible candidates for either team, whose extra expenses are defrayed. Again, the students themselves are aware of the danger, and have selected for treasurer a graduate and a business man who will save hundreds of dollars for the organization, besides by his influence in a quiet way acting as a check on any tendency to unnecessary or extravagant expenditures.

Though this officer has been in service only one year, the good results of his work already begin to manifest themselves, as the following figures will show. They are taken from a statement made at my request by the treasurer of the Financial Union. I quote from the letter, only making such changes as will render the statement clear to the general reader:

"I have given the total footings, you will see, of the expenses of the season of 1892 and also of the season of 1893. I have also given you all the items which ran over $1,000 on the expenses account. In comparing the total expenses, the comparison as given on this memorandum is from M——'s report, which was made the 1st of February, and H——'s report, at the same time in the year. It seems to be impossible to get in all the bills, so that the report shall be the same the 1st of February that it is when I hand in my final report of the year in the summer. For the sake of comparison, however, I would say this, that while M——'s report showed $15,284.62 expended when he put in his report, the total expenses of the football season of 1892, when closed up at the end of the college year, showed something over $1,000 more than this, and I should think the season of 1893 would show about the same addition. In either case, you see, it shows a saving in 1893 over the season of 1892, unless there are some outside bills which I, as treasurer, do not know about at present. In addition to that, we carried considerably more men in 1893.

"In the item of the training table, the sum shown on this report does not allow for the sum paid in by each man for his share of the board. As you know, it is the custom for each man to pay what he is paying regularly, so that from these items of the training table there would be a deduction of the amount paid in by the team. As this is not yet in, I have given you the figures as they stand without deducting the same. As nearly as I can calculate it now, Mr. C——, the manager, expects to get between five and six hundred dollars from this source, which would make the training table expenses pretty close down to $2,000. Mr. M——'s collections from the team were not as full as this, so that the saving at the training table will be even more than it appears in this memorandum I am sending you."

	Season 1892.	Season 1893.
Railroad expenses	$1,505 98	$1,303 00
Hotels	3,174 29	2,400 27
'Bus bills	1,004 88	1,026 45
Uniforms and shoes	1,494 50	2,001 49
Training table	2,937 30	2,798 86
Total expenses	$15,284 62	$13,171 95

Before leaving this subject it is only fair to say that there is one form of extravagance of which the football association is not guilty. They do not spend more than their income. They live very far within it. Combining with the baseball association in paying into the Financial Union their earnings, the two organizations more than make up the deficiencies of the others. After paying all bills of all the organizations the Financial Union is able to give $4,000 to the field association, $1,000 to the gymnasium, and still has a reserve fund for future contingencies.

Evil No. 3: Brutality. This is the hardest charge to meet, because there is such a difference of opinion as to what constitutes brutality. In the eyes of timid people any collisions between young men in the most properly conducted game would seem brutal, though these same collisions would be tame fun to the average schoolboy. Personal encounters of some kind seem absolutely necessary to the education of young men, especially young men of the strongest characters. Such young men, judiciously trained, constitute the best citizens of a State. A State full of such citizens becomes thereby the safest to live in, for such men are its best defense. At the dinner given by Colonel Higginson to the teams of Yale and Harvard, it was remarked by Mr. Ropes, the historian, that those nations which practiced semi-military games like football were not only the strongest nations, but that they were the least likely to rush into war; whereas other nations seemed to carry a chip on their shoulders, ready to fight on the smallest provocation. Certainly those who have been intimately acquainted with students and student life for the past twenty-five years can bear testimony not only to the decreasing brutality of college customs, but also to the generally mild and gentlemanly characters of the football players. They, by their influence and example in the college, have largely contributed to this better state of college life.

If violent encounters on the football field do lead to the temptation of inflicting needless personal injuries on an opponent, they also give opportunities for resisting this temptation, and consequently for the development of the highest forms of courage and self-control. According to the observations of the writer, these opportunities are embraced by the majority of the players. Only the minority yield to the temptation, and few of that minority attain to prominent places on a team. If the contrary were the fact, football would long ago have vanished from the list of college sports.

With reference to the evils of public contests—gate money and strains and injuries—the writer sees no reason to change the views already expressed.

"If field athletics are to continue, the expense of them must be

met in one of two ways, either by gate money or by subscriptions. Most young men prefer to give their money at the gate and thus to pay for what they see. If a club knows that it is to spend only what it earns, it will be stimulated, first, to play as good a game as possible; and, secondly, to spend its earnings with prudence. It seems only just, too, that, if the public desire to see a good game, they should pay for the exhibition. The men work hard in practice, and are entitled to have their expenses paid. More than that they do not ask. They do not play for gain but for honor.

"The evil of liability to strains and injuries in athletics can not be entirely obviated. It is well to bear in mind, at this point, the fact that even those who are not athletes do not, therefore, enjoy immunity from accidents. Yet so far, according to the recollection of the writer, no regular member of a Yale crew, team, or nine has been permanently injured by participating in a race or match. Still, it is possible that a slight injury, to a person having organic weakness, might result in a fatal difficulty. Such an issue might be avoided by the requirement that every candidate for trial should be examined by a competent physician, and, in default of procuring a certificate of physical soundness, should be excluded from participation in physical contests." *

As to particular rules looking to the improvement of the game, none but experts should speak.† Yet it might be allowed to those who are interested in it, and who have watched it closely, to make suggestions along the lines in which improvements should be attempted. The present style of mass play and momentum play puts a premium on weight and brute force. The mingling men in masses makes injuries more probable than in an open style of play. The mass play makes the game as little as possible a kicking game. It eliminates a great deal of the element of skill. Skill ought to be encouraged by setting some sort of premium on it. Increasing the number of points scored by a drop-kick from the field might accomplish this somewhat. Some changes in the rules regarding "interference" would do more. If, again, the "warnings" for "rough play" were entirely omitted and the umpire were instructed to send a man off the field at the first offense, captains would train their men to avoid these plays entirely. Then the experts, in reforming the game, could not do better than turn their attention to the umpires. If a plan for training umpires could be devised it would be a good thing. Not every good

* The Popular Science Monthly, March, 1884.

† Since this article was written the Committee on the Revision of the Rules of Football have met and recommended changes which are substantially in harmony with the suggestions made by the writer in this paragraph.

player, however fair-minded he may be, makes a good umpire. A man without experience as a player, but yet possessing a quick eye, a decisive will, and a knowledge of the rules of the game, might be a better umpire than the most famous player.

As to interference by the faculties in the way of measures limiting the game, I have already hinted at one, namely, the requiring a certificate of physical soundness for every candidate for athletic honors. I would also limit teams to undergraduates. This measure would bring the teams better under the control of faculty supervision, and would besides put a certain limit to competition. In the first place, the professional schools do not exercise a strict personal supervision over the students. They assume, and rightly, that a man who commences the study of a profession has begun the serious business of life, and is capable of directing his own time. He may be absent from every exercise of the school except the examinations. Passing those, he can still be a member of the school in good and regular standing. Such a student, when in competition for a place on the team with a member of the undergraduate department, who is held up to attendance on daily exercises, has a great advantage over him. His freedom from restraint exercises a pernicious influence on the man who is subject to restraint. Concert of action between the faculties of undergraduate departments and those of graduate and professional schools in the way of control of any sport is almost impossible from the very circumstances of the case.

Instead of appointing committees to act with the students in the regulation of the sports, a better way to control them would be the appointment of a director of athletics to a seat in the undergraduate faculty, who should be the medium of communication between the students and the instructors. Such a man ought to have the confidence of the students and be in sympathy with them. He ought also to be a gentleman and a scholar, a graduate of the college, and a man holding its best traditions of righteousness and scholarship sacred. Such a man would be alive to the responsibilities of both sides—of the scholarship side as represented by the instructors, and of the healthy boy side of student life. I would not have the mangement of athletics taken by him out of the hands of the students, but I would have him help them with advice and with instruction, too, if necessary. I would have him attend the practice games and the races, oversee the coaches and trainers, and watch the players and students. He could prevent, without recourse to "reporting to the faculty," repetitions of mistakes and follies on the part of the students. He could keep out bad men from the list of trainers. He could prevent many a promising lad from wrecking himself by making the excitement of college sport the be-all and end-all of his existence. By his

presence among the instructors he could, as opportunity offered, with timely words, fend off those sad mistakes which worthy gentlemen of the best intentions sometimes make in their dealings with boys—mistakes of which I think I am justified in saying that Yale has not often been guilty in the past fifteen years. The director would earn his salary if he did faithfully what his hand found to do.

If such men were appointed by all the colleges, and if joint action by the colleges at any time seemed desirable, these men would be best fitted to deal with questions which might arise, and would discover solutions of existing difficulties without recommending unpractical and impossible plans.

STUDIES OF CHILDHOOD.

III.—THE QUESTIONING AGE.

By JAMES SULLY, M. A., LL. D.,
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THE child's first vigorous effort to understand the things about him may be roughly dated at the end of the third year, and it is noteworthy that this synchronizes with the advent of the questioning age. The first putting of a question occurred in the case of Preyer's boy in the twenty-eighth month, in that of Pollock's girl in the twenty-third month. But the true age of inquisitiveness, when question after question is fired off with wondrous rapidity and pertinacity, seems to be ushered in with the fourth year.

A common theory peculiarly favored by ignorant nurses and mothers is that children's questioning is a studied annoyance. The child has come to the use of words, and with all a child's "cussedness" proceeds to torment the ears of those about him. There are signs, however, of a change of view on this point. The fact that the questioning follows on the heels of the reasoning impulse might tell us that it is connected with the throes which the young understanding has to endure in its first collision with a tough and baffling world. The question is the outcome of ignorance coupled with a belief in a possible knowledge. It aims at filling up a gap in the child's knowledge, at getting from the fuller knowledge of another some light on the scrappy, unsatisfying information about things which is all that his own observation can gather, or all that others' half-understood words have managed to communicate. It is the outcome of intellectual craving—a demand for food. But it is much more than an expression

of need. Just as the child's articulate demand for food implies that he knows what food is, and that it is obtainable, so the question implies that the little questioner knows what he needs, and in what direction to look for it. The simplest form of question—e. g., What is this flower, this insect?—shows that the child, by a half-conscious process of reflection and reasoning, has found his way to the truth that things have their qualities, their belongings, their names.

Questioning may take various directions. A good deal of the child's catechising of his long-suffering mother is prompted by thirst for fact.* The typical form of this line of questioning is "What?" The motive here is to gain possession of some fact which will connect itself with and supplement a fact already known. How old is Rover? Where was Rover born? Who was his father? What is that dog's name? What sort of hair had you when you were a little girl? These are samples of the questioning activity by the help of which the little inquirer tries to make up his connected wholes—to see things with his imagination in their proper attachment and order. And how greedily and pertinaciously the small people will follow up their questioning, flying, as it often looks, wildly enough from point to point, yet gathering from every answer some new contribution to their ideas of things! A boy of three years and nine months would thus attack his mother: "What does frogs eat, and mice, and birds, and butterflies? and what does they do? and what is their names? What is all their houses' names? What does they call their streets and places?" etc.

Such questions easily appear foolish because, as in the case just quoted, they are directed by quaint childish fancies. The child's anthropomorphic way of looking out on the world leads him to assimilate animal to human ways. Hence one value of these questionings as showing which way the current of the child's thought is setting. Hence, too, it would appear that not every child's question is to be answered. We may, however, set aside, or rather correct, the form of a child's question without treating it with an ill-deserved and quite inappropriate contempt.

One feature in this fact-gleaning kind of question is the great store which the child sets by the name of a thing. M. Compayré has pointed out that the form of question, "What is this?" often means "What is it called?" The child's unformulated theory seems to be that everything has its own individual name. The little boy just spoken of explained to his mother that he thought all the frogs, the mice, the birds, and the butterflies had names

* The first question put by Preyer's boy was, "Where is mamma?" That is an inquiry as to fact.

given to them by their mothers, as he himself had. Perhaps this was only a way of expressing the childish idea that everything has its name, primordial and unchangeable. A nameless thing may well seem to a child no less of a contradiction than a thing without any size. Perhaps, too, the name as an external sound joins itself to and qualifies the thing in a way that we, who are wont to employ words as our own created signs, can hardly enter into.

A second direction of this early questioning is toward the reason and the cause of things. The typical form is "why?" This form of inquiry occurred in the case of Preyer's boy at the age of two years and forty-three weeks. But it becomes the all-predominant form of question somewhat later. Who that has tried to instruct the small child of three or four does not know the long, shrill, whinelike sound of this question? This form of question develops naturally out of the earlier, for to give the "what" of a thing—that is, its connections—is to give its "why" —that is, its mode of production, its use and purpose.

Nothing, perhaps, in child utterance is better worth interpreting, hardly anything more difficult to interpret, than this simple-looking little "why?"

We ourselves, perhaps, do not use the word "why" and its correlative "because" with one clear meaning; and the child's first use of the words is largely imitative. What may be pretty safely asserted is that even in the most parrotlike and wearisome iteration of "why" and its equivalents "what for?" etc., the child shows a dim recognition of the truth that a thing is understandable, that it has its reasons if only they can be found.

Let us, in judging of this pitiless "why?" try to understand the situation of the young mind confronted by so much that is strange and unassimilated, meeting by observation and hearsay with new and odd occurrences every day. The strange things standing apart from his tiny familiar world, the wide region of the quaint and puzzling in animal ways, for example, stimulate the instinct to appropriate, to master. The little thinker must try at least to bring the new and the odd into some recognizable relation to this familiar world. And what is more natural than to go to the wise lips of the grown-up person for a solution of the difficulty? The fundamental significance of the "why?" in the child's vocabulary, then, is the necessity of connecting new with old, of illuminating what is strange and dark by light reflected from what is already matter of knowledge. And a child's "why?" is often temporarily satisfied by supplying from the region of the familiar an analogue to the new and unclassed fact. Thus his impulse to understand why pussy has fur is fully met by telling him that it is pussy's hair.

It is only a step further in the same direction when the "why" has to be met by supplying a general statement: for to refer the particular to a general rule is a more perfect and systematic kind of assimilation. Now we know that children are very susceptible to the authority of precedent, custom, general rule. Just as in children's ethics customary permission makes a thing right, so in their logic the fact that a thing generally happens may be said to supply a reason for any single thing happening. Accordingly, when the much-abused nurse answers the child's question, "Why is the pavement hard?" by saying, "Because pavement is always hard," she is perhaps less open to the charge of giving a woman's reason than is sometimes said.* In sooth, the child's queries, his searchings for explanation are, as already suggested, prompted by the desire for order and connectedness. And this means that he wants the general rule to which he can assimilate the particular and as yet isolated fact.

From the first, however, the "why" and its congeners have reference to the causal idea, to something which has brought the new and strange thing into existence and made it what it is. In truth, this reference to origin, to bringing about or making, is exceedingly prominent in children's questionings. Nothing is more interesting to a child than the production of things. What hours and hours does he not spend in wondering how the pebbles, the stones, the birds, the babies are made! This vivid interest in production is to a considerable extent practical. It is one of the great joys of children to be able themselves to make things, and the desire to fashion things which is probably at first quite immense, and befitting rather a god than a feeble child, naturally leads on to know something about the mode of producing. Yet from the earliest a true speculative interest blends with this practical instinct. Children are in the complete sense little philosophers, if philosophy, as the ancients said, consists in knowing the cause of things—"*causas rerum cognoscere.*" This is the completed process of assimilation, of the reference of the particular to a general rule or law. Everything remains a mystery, looks distant and foreign, until its history, its origin is ascertained, and it can be classed with the known things whose existence is accounted for.

This inquisition into origin and mode of production starts with the amiable presupposition that all things have been hand-produced after the manner of household possessions. The world is a sort of big house where everything has been made by somebody, or at least fetched from somewhere. This application of the anthropomorphic idea of fashioning follows the law of all

* Cf. some shrewd remarks by Dr. Venn, Empirical Logic, p. 494.

childish thought that the unknown is assimilated to the known. The one mode of origin which the embryo thinker is really and directly familiar with is the making of things. He himself makes a respectable number of things, including these rents in his clothes, messes on the table cloth, and the like, which he gets firmly imprinted on his memory by the authorities. And, then, he takes a keen interest in watching the making of things by others, such as puddings, clothes, houses, hayricks. To ask who made the animals, the babies, the wind, the clouds, and so forth, then, is for him merely to apply the more familiar type of causation as norm or rule. Similarly in all questions as to the "whence" of things, as in asking whether babies were bought in a shop.

The "why" takes on a more special meaning when the idea of purpose and adaptation of means to ends becomes clear. The search now is for the end, what philosophers call the teleological cause or reason. Here, again, the child sets out with the familiar type of experience, with human production and action as determined by aim. And it is easy for him, his mind being possessed by this anthropomorphic fancy which gives life to all things, to carry out this kind of inquiry. There is a stage in the development of a child's intelligence when questions such as "Why do the leaves fall?" "Why does the thunder make such a noise?" are answered most satisfactorily by a poetic fiction—by saying, for example, that the leaves are old and tired of hanging on to trees, and that the thunder-giant is in a particularly bad temper, and making a row. It is perhaps permissible to make use of this fiction at times, more especially perhaps when trying to answer the untiring questioning about animals and their doings—a region of existence, by the way, of which even the wisest of us knows exceedingly little. Yet the device has its risks; and an ill-considered piece of myth-making passed off as an answer may find itself awkwardly confronted by that most merciless of things, a child's logic.

But there is another sort of anthropomorphism in this interrogation. Children are apt to think not only that things in general are after our manner, but, what is very different, have their designs, so to speak, upon us. The sea, it will be remembered, made its noise with special reference to the ears of the small child C——. We may call this the anthropocentric idea—that is, the idea that man is the center of reference in the case of natural phenomena. This anthropocentric tendency is apt to get toned down by the temperament of a child, which is on the whole optimistic and decidedly practical, into a looking out for the *uses* of things. A boy, already quoted, once (toward the end of the fourth year) asked his mother what the bees do. This question he explained by adding "What is the good of them?" When told that they

made honey, he observed pertinently enough from his teleological standpoint, "Then do they bring it for us to eat?"

The idea underlying this questioning as to uses is the same idea which the theological optimists of the last century were wont to drive to such a surprising length. Their amusing speculations showed how far from easy it is to apply the idea to particular cases, and our small philosopher evidently saw the difficulty in the case of the bees, not by any means one of the most difficult.

A child's question may be prompted merely by ignorance and curiosity, or by a deeper motive, a sense of perplexity, of mystery, or contradiction. It is not always easy to distinguish the two types of question, yet in many cases at least its form, and the manner of putting, it will tell us that it issues from a puzzled and temporarily baffled brain. As long as the questioning goes on briskly, we may infer that a child believes in the possibility of knowledge, and does not know the deepest depths of intellectual despair. More pathetic than the saddest of questions is the silencing of questions by the loss of faith.

It is easy to see that children must find themselves puzzled with much which they see and hear of. The apparent exceptions to the rule don't trouble the grown-up persons, just because as *recurrent* exceptions they seem to take on a rule of their own. Thus adults, though quite unversed in hydrostatics, would be incapable of being puzzled by C——'s problem, why my putting my hand in water does not make a hole in it. Similarly, though they know nothing of animal physiology, they are never troubled by the mystery of fish breathing under water, which when first noted by a child may come as a sort of shock. The little boy just referred to, in his far-reaching zoölogical interogatory asked his mother, "Can they (the fish) breathe with their moufs under water?"

In his own investigations, and in getting instruction from others, the child is frequently coming upon puzzles of this sort. The same boy was much exercised about the sea and where it went to. He expressed a wish to take off his shoes and to walk out into the sea so as to see where the ships go to, and was much troubled on learning that the sea got deeper and deeper and that if he walked out into it he would be drowned. At first he denied the paradox (which he at once saw) of the incoming sea going uphill. "But, mamma, it doesn't run up, it doesn't run up, so it couldn't come up over our heads?" He was told that this was so, and he wisely began to try to accommodate his mind to this startling revelation. C——, too, was much exercised by this problem of the moving mass of waters, wanting to know whether it came halfway up the world. Probably in both these cases the idea of water rising had its uncanny, alarming aspect.

We have seen that the disappearance of a thing is at a very

early stage a puzzle to the infant. Later on, too, the young mind continues to be exercised about this mystery. Our little friend's inquiry about the whither of the big, receding sea, "Where does the sea sim (swim) to?" illustrates this perplexity. A child seems able to understand the shifting of an object of moderate size from one part of space to another, but his conception of space is probably not large enough to permit him to realize how a big tract of water can pass out of the visible scene into the unseen. The child's question, "Where does all the wind go to?" seems to have sprung from a like inability to picture a vast unseen realm of space. C——'s question as to where all the days go to may have been prompted by the idea that the days or their scenic contents continue to exist somewhere; that the past is something like the unseen region of space into which things disappear as they move away from us.

In addition to this difficulty of the disappearance of big things, there seems to be something in the vastness, the infinite quantity and number of existents perceived and heard about, which puzzles and oppresses the young mind. The inability to take in all the new facts leads to a kind of resentment at their multitude. "Mother," asked a boy of four years, "why *is* there such a lot of things in the world if no one knows all these things?" One can not be quite sure of the underlying thought here. Did the child mean merely to protest against the production of so confusing a number of objects, or was there a deeper difficulty, a dim presentiment of Berkeley's idealism, that things can exist only as objects of knowledge? This surmise may seem far-fetched to some, yet I have found what seem to me other traces of this tendency in children. A girl of six and a half years was talking to her father about the making of the world. He pointed out to her the difficulty of creating things out of nothing, showing her that when we made things we simply fashioned materials anew. She pondered and then said, "Perhaps the world's a fancy." Here, again, one can not be quite sure of the child-thought behind the words. Yet it certainly looks like a falling back for a moment into the dreamy mood of the idealist—that mood in which we seem to see the solid fabric of things dissolve into a shadowy phantasmagoria.

The subject of origins is, as we know, beset with puzzles for the childish mind. The beginnings of living things are of course the great mystery. "There's such a lot of things," remarked the little zoölogist I have recently been quoting, "I want to know, that you say nobody knows, mamma. I want to know who made God, and I want to know if pussy has eggs to help her make ickle (little) kitties." Finding that this was not so, he observed, "Oh, then, I s'pose she has to have God to help her if she doesn't have kitties in eggs given her to sit on." Another little boy, five years

old, found his way to the puzzle of the reciprocal genetic relation of the hen and the egg, and asked his mother: "When there *is* no egg, where does the hen come from? When there *was* no egg, I mean, where *did* the hen come from?" In a similar way as we saw in C——'s journal a child will puzzle his brains by asking how the first child was suckled, how the first chicken-pox was acquired, how the first man learned to speak (without any example).

The allied mystery of growth is also a frequent theme of this early questioning. "How" (asked one little three-year-old questioner) "does plants grow when we plant them? and how does boys grow from babies to big boys like me? Has I grown now while I was eating my supper? See!" and he stood up, to make the most of his stature. It would be funny to know all a child's speculations on this supremely interesting matter of growth. But of this more by and by.

Much of this questioning is metaphysical, in that it transcends the problems of every-day life and of science. The child is metaphysician in the sense in which the earliest human thinkers were metaphysicians, pushing his questioning into the inmost nature of things, and back to their absolute beginnings. He has no idea yet of the confines of human knowledge. If his mother tells him she does not know, he tenaciously clings to the idea that somebody knows—the doctor it may be, or the clergyman, or possibly the policeman, of whose superior knowledge one little girl was forcibly convinced by noting that her father once asked information of one of these willing officials.

Strange, bizarre, altogether puzzling to the listener are some of the child's questions. The "why" is applied to everything in a most bewildering fashion. A little American girl, of nine years, after a pause in talk, recommenced the conversation by asking, "Why don't I think of something to say?" A play recently performed in a London theater made precisely this line of questioning a chief amusing feature in one of its comical characters. Another little American girl, aged three, one day left her play and her baby sister, named Edna Belle, to find her mother and ask, "Mamma, why isn't Edna Belle me, and why ain't I Edna Belle?" * The narrator of this story adds that the child was not a daughter of a professor of metaphysics but of practical farmer folk. One can not be quite sure of the precise drift of this question. It may well have been the outcome of a new development of self-consciousness, of a clearer awareness of the self in its distinctness from others. A question with a much clearer metaphysical ring about it, showing thought about the subtlest prob-

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* Quoted from an article, Some Comments on Babies, by Miss Shinn, in the Overland Monthly, January, 1894.

lems, was that put by a boy of the same age: "If I'd gone upstairs, could God make it that I hadn't?"

All children's questioning does not, of course, take this sublime direction. Along with the tendency to push back inquiry to the unreachable beginning of things we mark a more modest and scientific line of investigation into the observable and explainable processes of Nature. Some questions which a busy listener would pooh-pooh as dreamy have a genuinely scientific value. showing that the little inquirer is trying to work out some problem of fact. This is illustrated by a question put by a little boy aged three years and nine months. "Why don't we see two things with our two eyes?"—a problem which, as we know, has exercised older psychologists.

When this more definitely scientific direction is taken by a child's questioning we may observe that the ambitious "Why?" begins to play a second rôle, the first being now taken by the more modest "How?" The boy Clerk Maxwell, with his incessant inquiries into the "go" of this thing or the "particular go" of that, illustrates this early tendency to direct questioning to the more manageable problems to which science confines itself.

These different lines of questioning are apt to run on concurrently from the end of the third year, a fit of eager curiosity about animals or other natural objects giving place to a fit of theological inquiry; this, again, being dropped for an equally eager inquiry into the making of clocks, railway engines, and so on. Yet through these alternating bouts of questioning we can distinguish something like a law of intellectual progress. Questioning as the most direct expression of a child's curiosity follows the development of his groups of ideas and of the interests which help to construct these. Thus I think it a general rule that questioning about the make or mechanism of things follows questioning about animal ways just because the zoölogical interest (in a very crude form, of course) precedes the mechanical. The scope of this early questioning will, moreover, expand with intellectual capacity, and more particularly the capability of forming the more abstruse kind of childish idea. Thus, inquiries into absolute beginnings, into the origin of the world and of God himself, indicate the presence of a larger intellectual grasp of time relations and of the processes of becoming.

Our survey of the field of childish questioning suggests that it is by no means an easy matter to deal with. It must be admitted, I think, by the most enthusiastic partisan of children that their questioning is of very unequal value. It may often be noticed that a child's "Why?" is used in a sleepy, mechanical way, with no real desire for knowledge, any semblance of answer being accepted, without an attempt to put a meaning into it. A good

deal of the more importunate varieties of children's questioning, when they follow up question by question recklessly, as it seems, and without definite aim, appears to be of this formal and lifeless character, an expression not of a sound intellectual activity, but merely of a mood of general mental discontent and peevishness. In a certain amount of childish questioning, indeed, we have, I suspect, to do with a distinctly abnormal mental state, with an analogue of that mania of questions or passion for mental rummaging or prying into everything—*Grübelsucht*, as the Germans call it—which is a well-known phase of mental disease, and in which the patient will put such questions as these: "Why do I stand here where I stand?" "Why is a glass a glass, a chair a chair?" * Such questioning ought, it is evident, not to be treated too seriously. We may attach too much significance to a child's question, laboring hard to grasp its meaning, with a view to answering it, when we should be wiser if we viewed it as a symptom of mental irritability and peevishness, to be got rid of as quickly as possible by a good romp or other healthy distraction.

To admit, however, that children's questions may now and again need this sort of wholesome snubbing is far from saying that we ought to treat all their questioning with a mild contempt. If now and then they torment their elders with a string of random, reckless questionings, in how many cases, one wonders, are they not made to suffer—and that wrongfully—by having perfectly serious questions rudely cast back on their hands? The truth is, that to understand and to answer children's questions is a considerable art, including a large and deep knowledge of things, and a quick, sympathetic insight into the little questioners' minds. It is one of the tragi-comic features of human life that the ardent little explorer, looking out with wide-eyed wonder upon his new world, should now and again find as his first guide a nurse or even a mother who will resent the majority of his questions as disturbing the luxurious mood of indolence in which she chooses to pass her days. We can never know how much valuable mental activity has been checked, how much hope and courage cast down, by this kind of treatment. Yet happily the questioning impulse is not easily eradicated, and a child who has suffered at the outset from this wholesale contempt may be fortunate enough to meet, while the spirit of investigation is still upon him, one who knows and who has the good nature and the patience to impart what he knows in response to a child's appeal.

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* See W. James, Psychology, vol. ii, p. 284.

THE AMERICAN CHAMPAGNE DISTRICT.

By LEE J. VANCE.

TWO hundred years ago a pious monk, Dom Perignon by name, held the post of cellarer to the fraternity of monks of the Order of St. Benedict, in the hamlet of Hautevillers, situated on the river Marne, four or five miles from Epernay and about fifteen miles from Rheims. His was an important position, for the revenues of the abbey depended entirely on its vineyards, and consequently on the taste, judgment, and skill of its cellarer. Consider what this pious monk did to increase the revenues of the abbey.

The important contributions that Dom Perignon made to the art of wine-making were the result of observations and experiment. Thus, he noticed that the wine which was made from the grapes growing in the different vineyards of the district showed, as might be supposed, different characteristics. For example, the black grapes produced a white wine that improved with age, instead of turning yellow and deteriorating as did the wine made from white grapes. This set Dom Perignon to thinking. Then the happy idea suggested itself to him of "marrying" the different wines produced in the vineyards of the district. Why not blend the juice of the black grapes with that of the white grapes? Now, Dom Perignon, be it said, was an artist. He tried many different mixtures until he obtained one or two wines that satisfied his nice and cultivated taste.

If Dom Perignon had been content to manufacture wine by the ancient and time-honored methods of his predecessors, he would never have discovered the light, sparkling wine which has made the Champagne district of France known the world over. His first discovery, the blending of certain wines, which was the result of care and thought, led in turn to his second and greatest discovery—the secret of sparkling wines—which, oddly enough, came by accident. One day a tightly corked bottle in the cellar exploded, and lo! to the monk was revealed the mystery of effervescence, and *vin mousseux*—what we call champagne—was the glorious result.

The new wine met with immediate favor and great success. It revolutionized the art of wine-making; it was a revelation to wine-drinkers. Sparkling wine was so far beyond the old-style still wine that the two could not be compared in the same breath. The delicious and original qualities of *vin mousseux* are a fine color, a snap, a sparkle, and "beaded bubbles winking at the brim," a quick, fleeting taste to the tongue, an almost imperceptible bouquet, and last but not least a subtle, exhilarating effect.

Fig. 1.—Tying Grapes in Summer.

The straw-white wine from the Champagne district, especially from Hautevillers, became famous during the reign of Louis XIV. The king contributed to bring the new wine into fashion by having it on the royal table. The great wine connoisseur of the day, Marquis de Sillery, at a *souper d'Anet*, introduced champagne in flower-wreathed bottles, which, at a given signal, a dozen blooming damsels in the guise of Bacchanals placed upon the table.

Thus heralded, champagne became *par excellence* the wine of civilization. So Talleyrand in his epigrammatic way called it, "*vin civilisateur par excellence.*" In England, at the beginning of the present century, champagne was the necessary adjunct to all public and private banquets. No formal affair was complete without it. And yet, ninety, eighty, seventy, or sixty years ago the amount of champagne made and required was comparatively small. Indeed, it is only within the last forty or fifty years that the consumption of champagne has increased by "leaps and bounds." It has increased fourfold within thirty years; it has doubled within the past fifteen years; and in this connection, it is significant to note that the growing demand for champagne has come, not from France, but from foreign countries, principally from Russia, England, and America. Five times as much champagne is required outside of France as is used for home consumption.

The extraordinary demand for champagne stimulated the wine-makers of other grape-growing districts and of other countries to produce a genuine *vin mousseux*. The result is, there are many *sparkling wines*—for example, the sparkling wines of Germany and Austria—but only one kind of champagne, and that is made in the Champagne district of France.

The earliest attempt at the manufacture of champagne on a commercial scale in the United States was made in Ohio about the year 1850. At that time there were extensive vineyards in the Ohio Valley. The pioneer and promoter of an American champagne industry was the Hon. Nicholas Longworth, of Cincinnati. He procured expert and capable wine-makers, and imported improved machinery and appliances from the Champagne district of France. He was fairly successful in making a sparkling Catawba wine. For several seasons—that is, from 1862 to 1865—the vines were attacked by pests and fungoid diseases; the vineyards of the Ohio Valley were destroyed, and the champagne business ruined. Since then the grape and wine industry has been transferred to the northern part of Ohio, along the shores of Lake Erie, and a small amount of champagne is now made at Kelley's Island, Toledo, and Sandusky; also at St. Louis, Mo.

Meanwhile the lake region of central New York was rapidly coming to the front as the land of vineyards. We refer to the

country around three lakes—Keuka, Seneca, and Canandaigua. The grape industry was started along Lake Keuka about fifty years ago. The first outdoor grapes were shipped to the New York market about 1847–'48 by the way of the Erie Canal. In 1860 the Lake Keuka grape industry was well rooted, and there were planted and in bearing about 250 acres.

At the present time there are about 16,500 acres of vineyards in the Lake Keuka district. To this should be added about 10,000 acres of vineyards in the Seneca and Canandaigua districts, making a total of 26,500 acres in the lake region. In the western part of the State is the Chautauqua district, which contains about 18,000 acres of vineyards. The Hudson River district, which was established about 1860, has about 14,000 acres of vines.

In 1890,* when the statistics of viticulture were gathered for the first time in the United States, it was found that New York State, with one fourth of the acreage of California, raised almost twice as many table grapes as the latter State. In other words, four fifths of the grapes grown in New York are for table purposes, while in California four fifths of the grapes are made into wine.

The American champagne district, as the Lake Keuka region has been known for some time, is fairly entitled to its name. More and better champagne is produced annually in this district than in any other section of the United States. The first wine company, the Pleasant Valley, was formed in 1860, and a few years later began making champagne. In 1865 the Urbana Wine Company was organized, with the object of making a superior American champagne. These two cellars each carry a stock of 1,000,000 bottles of champagne. There are five other cellars in the district, all making champagne, and ranging in capacity from 30,000 to 150,000 gallons.

East of the Rocky Mountains no champagne in any quantity is made outside of Ohio and New York. West of that great range considerable champagne has been made in one section of California, but the Eastern product is regarded by connoisseurs as more nearly approaching in quality the best French product. There is, and will be, a difference between the best American and French champagnes, owing to the variety of grapes and soils, but outside of that, as a chemical analysis will show, the difference is no greater than that between French champagnes produced in the several localities of the Champagne district.

It is now well understood that the golden qualities of *vin*

* In that season the New York growers shipped to market the enormous quantity of 60,687 tons, or 121,374,000 pounds, of table grapes, while California sold only 38,785 tons for the same purpose.

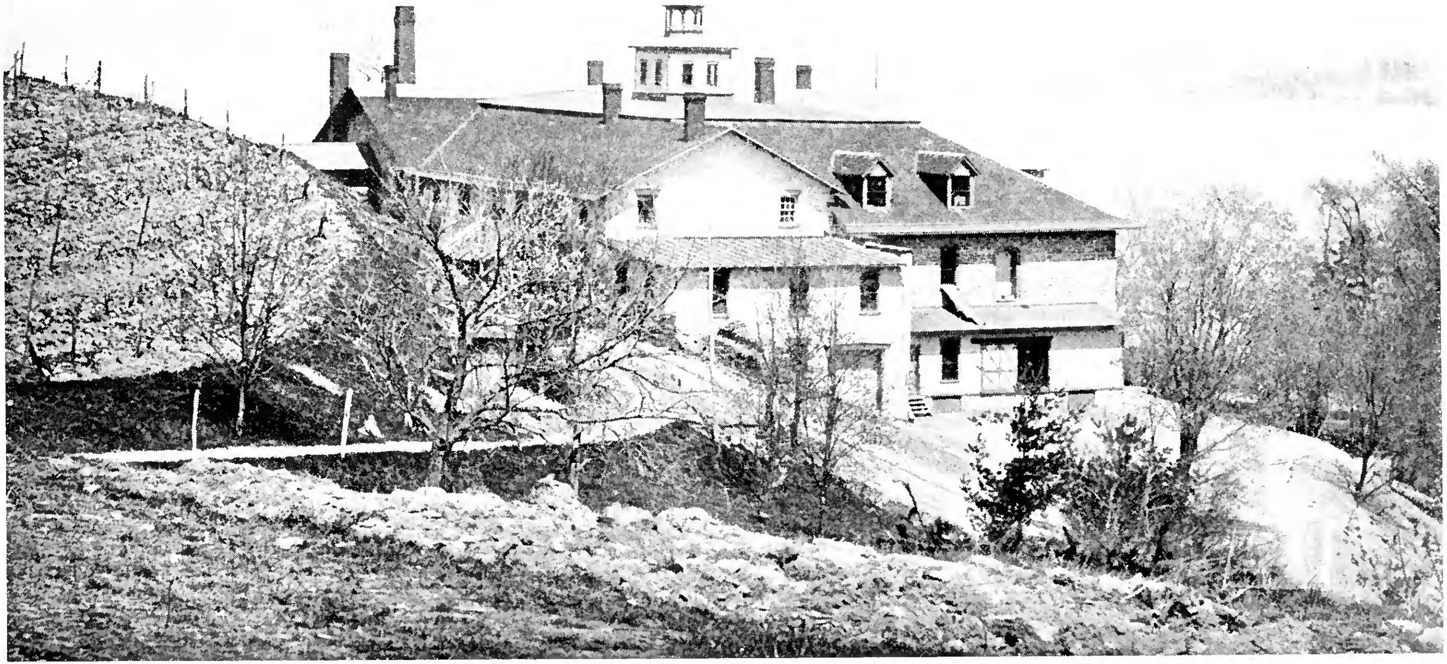

FIG. 2.—THE LAKE KEUKA VINEYARD COUNTRY.

mousseux may be attributed to three elements: (1) The variety of grape; (2) the soil and climatic conditions; and (3) the manipulation. The grapes of which the French wine is made grow on a soil which is peculiar in its mixture of chalk, silica, light clay, and oxide of iron. The surface of the champagne district is composed of light clay and pebbles, and the vine flourishes best where the soil appears most sterile. Hence, while the grapes for champagne contain but little sugar, they draw from the earth those chemical elements that give certain peculiar qualities to the wine.

When viticulture was introduced into this country, more than one hundred years ago, efforts were made to grow the European varieties of grapes east of the Mississippi. With few exceptions, these foreign varieties turned out to be failures. Then our Eastern viticulturists directed their attention to the improvement of native vines. By dint of experiment after experiment they have succeeded in developing some of the choicest and most valuable varieties of grapes known—varieties good for the table as well as for wine-making.

The two great native grape stocks are the Concord and the Catawba. From the seedlings of the Concord we have obtained Worden, Moore's Early, Pocklington, Martha, and other well-known varieties. The Concord is also one parent of Niagara, El Dorado, Brighton, etc. From the Catawba we have obtained Iona, Diana, Excelsior, etc. The Delaware and Isabella have given us a few good varieties. Some idea of the varieties of native grapes can be gained from the statement that two hundred and seventy-five varieties of grapes were sent by Eastern growers to the horticultural exhibit at the World's Fair, Chicago.

The wonderful improvement of our wild American grapes is striking testimony to man's power of selection. He has transformed sourish, harshly flavored wildlings into sweet, luscious fruit. In this process there has been an evolution of the sense of taste. Our grandfathers and fathers ate sour grapes, but the children's teeth have not been set on edge, because they eat sweet grapes. The difference between a lemon and an orange represents the improvement of the grapes of the present day over the grapes of fifty years ago.

Somewhat different has been the history of viticulture in California. There, efforts to grow the European varieties of grapes were successful from the first. The California growers did not have to experiment with native vines. Numerous varieties of the foreign species *Vitis vinifera* were planted and cultivated, and, in the right climate and soil, they showed their Old World characteristics. Many of the choice kinds of French, German, Italian, and Spanish types seem to come nearer to reproducing themselves here than elsewhere.

California may be divided into three grape-growing sections: (1) The coast, (2) the Sierra Nevada foothills and Sacramento Valley, (3) the southern counties. In the first district are grown varieties of French champagne grapes, from which are produced large quantities of sparkling wines. The Sierra Nevada foothills are best adapted, as the Director of the Experiment Stations has pointed out, to the growing of sherry, port, and raisin grapes, while the slopes and valleys of the Coast Range must be looked to for wines of the claret, burgundy, and sauterne types.* The southern district of California excels in sweet wines and brandies. Here the Muscat varieties are grown for table use and for raisins.

Thus, the differences between the two great grape-growing sections of the United States are clearly defined. The grapes raised in New York and Ohio—in fact, all those raised east of the Rocky Mountains—are native varieties and contain but little sugar. They yield the delicate table wines and champagne. The grapes raised west of the Rockies, especially in California, are European varieties and are heavy in sugar. They produce brandies, the demi-liquor wines, such as sauterne, and the heavy liquor wines, such as sherries, madeiras, and ports. Hence the methods of wine-making in California are quite different from those in Eastern States.

The Eastern district possesses many points in common with the French vineyard districts. The Lake Keuka country is a fine grape-growing region, owing to the peculiar climatic and other natural advantages that it enjoys.

Here is the proper place to observe that the best grape localities or climates are those where dews are light or altogether absent. It is a matter of experience that grape culture has become popular and profitable only in such localities. It is so in the champagne district of France along the river Marne, or in the Medoc district stretching north from Bordeaux between the sea and the rivers Garonne and Gironde, and in Germany along the river Rhine. It is so in the United States, along the Hudson River, along the lakes of central and western New York, and in the strip of territory extending along the shores of Lake Erie. In all of these grape-growing regions the vines are exempt from heavy or frequent dews and fogs, on account of the presence of considerable bodies of water.

It is to these climatic conditions that the Lake Keuka grape industry owes its success. The vineyards are always under the protecting presence of Lake Keuka, and under the guard of the high hills that surround it. Here the grape is enabled to escape

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* See report for 1889.

its most dangerous enemy—early frost. The spring comes late, as the crust of ice on the lake keeps the water and air cold, and retards the opening of the buds until the usual danger of frost is past. The water exerts a similar favorable influence in autumn, by retaining the heat collected during the summer, so that the fruit is protected from early frosts in September. The presence of this stratum of air is shown by the absence of light frosts during late autumn, and by the greenness of the foliage where the

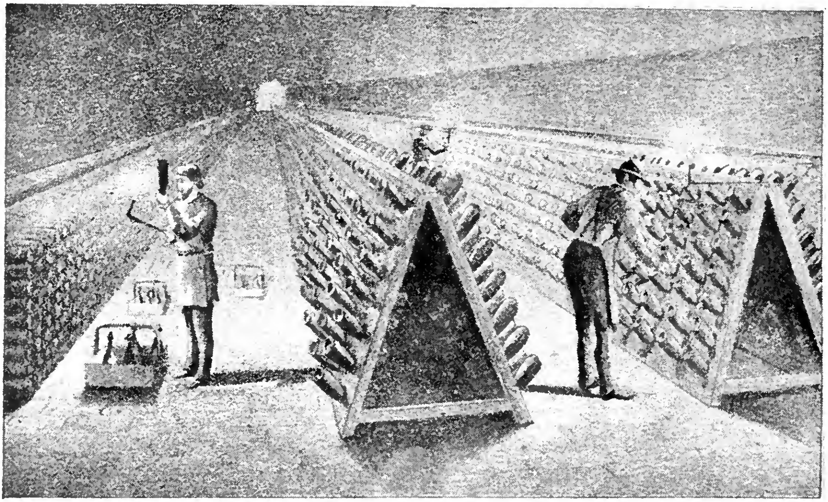

Fig. 3.—Champagne Vault.

warm breezes from the lake extend. There is a difference of from six to ten degrees between the temperature near the lake and that on the hilltops.*

The soil is also another important factor in the successful growing of grapes. The surface of the Lake Keuka hillsides is composed of gravel and shale on calcareous rock. It looks bare, having been washed off by rainstorms and freshets centuries ago. There are places where vegetation is stunted, and where weeds find no great encouragement; and yet the finest Catawba vines flourish in soils that appear little better than gravel beds. You wonder how grapes can grow and sweeten on such ground. The reason is, that in such earth the soil retains the sun's heat long

* The influence of water in ameliorating climate is seen in the varieties of native grapes that flourish in certain localities. The *labrusca* stock is a native east of the Alleghany Mountains, and is suited to a moist climate. It does not do well or flourish in the dry regions of the Western and Southwestern States. The *bourquiniana* varieties, such as *herbemont*, are eminently dry climate grapes. The *æstivalis* of the South and the native viparias of the Northwest are best fitted to their environment.

after sundown, so that the work of fructification goes on silently by night as by day.*

A few words as to the methods of cultivation that obtain in the Lake Keuka district. The vines are set from six to eight feet apart, and are trained to run on trellises. Three lines of wire are stretched from stakes, which are about eight feet distant from each other. The vines begin bearing in the third year, and the yield increases until the fifth and sixth years, when a vineyard is said to be in full bearing. The life of a vineyard is often three score and ten years, so that with good care and attention the children may reap from the vines their fathers planted. The average yield is about two tons of Catawba grapes to the acre, while the Concords will often go four tons to the acre.

In the fourth year the vine, if it has made good growth, is trimmed with two arms. The method of training is known as the "horizontal arm and spur system." By this system two main horizontal branches, or canes, are trained permanently to the lower wires—one to the right, another to the left. The upright shoots, that grow from the two main arms each season, are cut back each fall or winter to upright "spurs." The strongest new shoots that spring from these spurs in the spring are left for the bearing wood of that season, and this new cane is headed back to the top wire of the trellis. A strong vine will carry four shoots on each arm, or eight in all, care being taken not to overload the vine.

The method of pruning is known to growers as the thorough renewal system. When the spurs on the two main arms become overgrown or rank, they are renewed from new shoots, which spring from the arm, or near the base of the vine. Sometimes the arm itself is renewed from the head of the vine, or from a point near the ground. Summer pruning consists in thinning the vines here and there, and cutting off damaged clusters and imperfect berries.

As soon as the frost is out of the ground the grower goes through his vineyard to see if it has wintered well—that is, if post, wires, and vines are in good shape. A few weeks later, the canes are tied by willow bands to the lower wire. During May and June the vineyard is plowed and the roots grubbed. The first

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* The peculiar climatic and other natural advantages of the Lake Keuka region are summed up by William Saunders, Government Superintendent of Gardens and Grounds, as follows: "Here the Catawba and other late grapes mature and reach remarkable perfection, taking the latitude into consideration. These vineyards are mostly on the hillsides extending for several hundred feet above the valley and surface of Keuka Lake. The soil is a drift formation, and the surface is thickly covered with loose shale. The marked adaptability of this locality for grape culture may be attributed to its elevation and nature of the soil."—(*Report of Secretary of Agriculture for 1889, p. 113.*)

plowing is away from the vines, and in the second and third it is toward the vines. During the summer the vines grow vigorously, and the climbing offshoots are tied by straw bands to the second and third wires.

The algebraic x stands for the unknown quantity in grape-growing—for bad weather, diseases and pests. A few years ago the Lake Keuka vineyards were attacked by "black rot." At one time it looked as if the industry would be wiped out as completely as it was in the Ohio Valley thirty years ago. But the remedy known as the "Bordeaux mixture" proved to be the salvation of the grape-grower. It is a composition of six pounds each of sulphate of copper and lime to fifty gallons of water. This is sprayed

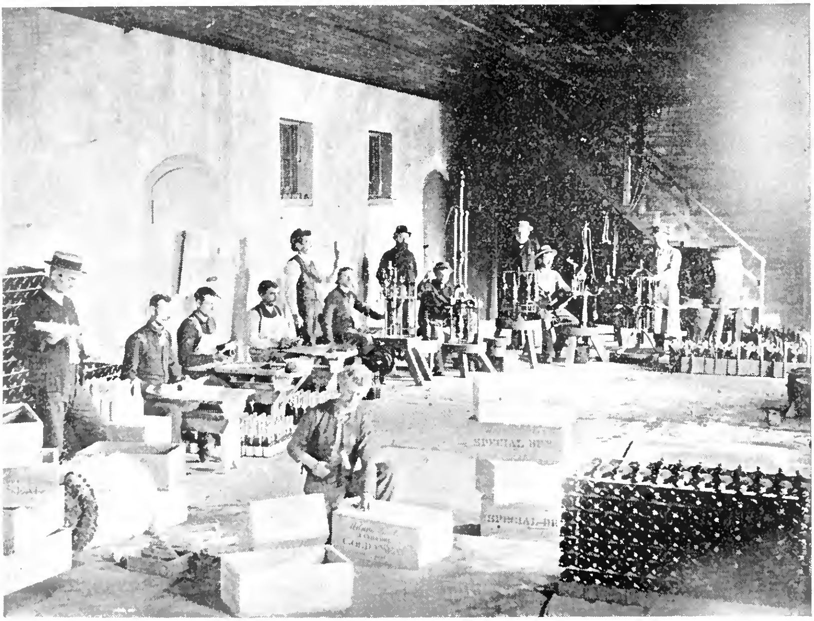

FIG. 4.—FINISHING CHAMPAGNE.

on the vines three times during the season: first, when the blossoms begin to appear; second, just after blossoming and when the fruit has set; third, when the grapes are partly grown. For the last spraying many growers use a copper carbonate ammoniacal solution.

The vintage begins the first week in September and lasts until the third week in October. It depends, of course, on the weather and on the kind of grapes grown. The Delawares ripen first, then the Concords, while the Catawbas seldom mature before the first week in October. The grape crop is picked in boxes which hold from thirty to forty pounds. When filled they are carried to the

end of the rows, and there gathered two or three times a day and drawn to the packing house. The fruit that is not packed in boxes for market is stored in crates or on trays and, by proper ventilation and temperature it can be kept fresh and fair for several months. This gives the grower a long range of season, and choice table grapes are supplied from October till the following March or April.

This grape-picking time is a kind of long and pleasant picnic—all the more pleasant for being a busy one. The men and women look forward to it from year to year as a chance to earn money to carry them through the winter, while the young people regard the season as one of recreation and enjoyment. The most expert pickers are the women and girls. They come from the neighboring farms and country villages. The usual rate of wages is one dollar per day without "board," or three dollars per week with board.

The Lake Keuka grape crop is sent to market in small baskets. Last year (1893) the number of cars shipped from the district was not less than 2,200. As each car holds from 2,500 to 2,700 baskets, the reader can form some correct idea of the quantity of grapes produced annually in this one district. The bulk of the crop is sent to the Eastern cities—New York, Philadelphia, and Boston. The growers send table-grapes as far west as Omaha and Denver, and last season several carloads were shipped to the Northwest, and even to Manitoba.

At the present time the wine cellars take a very small per centage of the total crop. It is estimated that the twelve wineries in the Keuka Lake district use from 5,000 to 6,000 tons of grapes during the season. There is now an overproduction of grapes for table purposes. The growers look to the growing wants of the wine cellars to take their surplus crop. With the increasing demand for American wines, especially for champagne and delicate table wines, the time should be not far distant when the output of the cellars will be ten times as great as it is to-day.

Of course, the reader will be interested in learning how the pure, sweet juice of the grape is converted into lively, sparkling champagne. There is more or less of a veil of secrecy thrown around the ways and methods of the champagne-maker; for he is an artist and does not wish to disclose the mysteries of his art. What follows concerning the various processes through which the wine goes in its successive stages is the result of a visit made last autumn to the largest establishment of its kind in the United States.

The building of A. B. & Co. is on the shore of the lake, and, being constructed of huge blocks of quarried stone, looks like a mediæval castle. The outside gives one little notion of the size and capacity of the establishment. There are fourteen separate

vaults, or cellars, and these extend far under the hill. Together they are one hundred and thirty-two feet long and one hundred and five feet wide. Stored underground are one million bottles of champagne made by the French method—i. e., by fermentation in the bottle.

You enter: the nostrils are tickled with the odor of the wines. You see the vats heaped full with luscious grapes; the two double wine presses are working and squeezing out the life-blood of the berries; the liquid stream is pouring into large tanks; the men are bare-armed, their hands and faces smeared with red stains—you see this, and can imagine Bacchus and his merry crew holding high carnival.

This new wine, or "must," after it deposits its lees in the course of a few days, is run into casks holding from two to four thousand gallons each. Here it remains for six or eight weeks—that is, until it has passed through its first fermentation. Then it is racked off into other casks, and is now ready for mixing.

The composition of the blend is, of course, one of the secrets of the art. The French wine-maker mixes the juice of black grapes with that of white grapes in the proportion of three to one. The American wine-maker does about the same. He takes juice of the black Concord and Isabella grapes and mixes it with that of the red Catawba, Iona, and Delaware grapes. The great point is to get the right amount of saccharine matter, so as to cause neither too much nor too little effervescence: if too much, the bottles break afterward; if too little, the wine becomes dull, flat, and insipid. Thus the *cuvée* is effected. Think of the delicacy of taste required in order to *know* what the juices of many different grapes will bring forth two years hence! The mixture is put into casks in which it undergoes the process of fining, and then it is ready for bottling. After being bottled, the wine is kept in a semi-warm room until fermentation is well begun. The bottles are then carried to the deep, cool vaults, where they are packed in horizontal layers, making a pile four or five feet deep and twelve or fifteen feet long. Thus the bottles remain until the wine within is fully ripe—a period of from twelve to eighteen months.

It is important that the vaults be kept at an equable temperature. This is accomplished by the cold storage system, and the thermometer will not show a variation of more than three degrees throughout the year. The bottles are of great strength and of foreign make. The loss from breakage is always considerable, ranging from five to fifteen per cent. It is one of the items of the extra expense of champagne; the others being the quality of the juice, the care and manipulation required, and the capital invested for two or three years.

When champagne is considered fully ripened, the bottles are

placed upon clearing tables, or racks, the necks pointing obliquely downward, in order that the sediment which has been formed during fermentation may work down upon the cork. Twice a day for three or four weeks the workmen give the bottles a quick little shake, and turn them partly around and down. At the end of this time the sediment is in the neck of the bottle, while the body of the wine is clear.

Now the bottles are taken to the finishing room, cork down, and the sediment is "disgorged." The workman cuts the cord holding the cork, and zip! out shoots the sediment with a report. The bottle is quickly placed on a machine and supplied with a temporary cork.

The wine in this state is raw—*vin brut*—without any *liqueur*. It is sharp and not cloying to the taste. It must be sweetened. So the bottle is placed in a machine, and a spoonful of *liqueur* is injected into it from a graduated glass tube or reservoir. This "dosage," as it is called, is simply pure sugar crystal dissolved in old wine or fine brandy. The dry champagne which the English and Americans like contains from four to eight per cent of *liqueur;* the Russians like sweet champagne, which has from fifteen to twenty per cent of *liqueur*.*

The bottle is permanently corked, and passed to a workman who ties in the cork and fastens wire around it. An ingenious capping machine puts on the pretty gold and silver foil that decorates the bottle, and finally the label is pasted on and the wine cased.

Such, in brief, are the successive stages through which champagne must pass ere it reaches the table with a bird and is called a "cold bottle." During these processes each bottle has been handled about two hundred times, and the transition from the grape to the finished product has taken two years and a half of time. There is, however, a short cut to champagne. Man does in a few days or a week what it takes Nature to accomplish in two years. He forces carbonic gas into the wine, and he even imitates closely the different bouquets. All is not champagne that sparkles.†

Champagne! There is an indescribable charm over, around, and about thee. The very word suggests glitter and bubble and

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* The word "dry" is used by wine-growers to indicate natural-juice wine, such as claret or Rhine wine, in which no sugar is left after fermentation. As applied to champagnes, "dry" is used to indicate the degree of sweetness, as "dry" and "extra dry" or "special dry." We do not undertake to pass on the comparative merits of the French and American champagnes.

† The apparatus for charging wine and formulas for imitating bouquets are given in Antonio dal Piaz's book, Die Champagner-Fabrikation und Erzeugung imprägnirter Schaumweine. Wien, 1892.

sparkle. It brings to many of us a flood of recollections: pleasant company—bright eyes and rosy cheeks—laughter, sunburned mirth, and Provençal song—the feast of reason and flow of soul—the flow of words, repartee and banter—after-dinner speeches, and dull, formal dinners—all jumbled together. Even at this late day many a Cassio listens to the voice of the tempter Iago, who says: "Come, come; good wine is a good familiar creature, if it be well used; exclaim no more against it!"

SOME LESSONS FROM CENTENNARIANS.

By J. M. FRENCH, M.D.

AN examination of the Massachusetts registration reports reveals some facts with reference to centennarians which are of interest, both in themselves considered and as illustrating some of the conditions favorable to great longevity.

The whole number of persons who died in Massachusetts during the ten years from 1881 to 1890, inclusive, at the age of one hundred years or over, was 203. The whole number of deaths reported during the same time was 394,484, making the proportion of centennarians one for every 1,928 of all deaths reported.

Dr. Farr, the celebrated English registrar general, in his March of an English Generation through Life, states that out of every 1,000,000 persons born in England only 223 live to the age of one hundred years. This is one in 4,484, or less than one half the proportion in Massachusetts. It must be remembered, however, that in respect to certain elements the conditions in the two cases are not parallel; inasmuch as, in the first place, the returns of deaths, especially of infants and young children, are much less complete in Massachusetts than in England; and, in the second place, a large proportion of persons of the younger ages are constantly going out from Massachusetts to settle in the newer portions of our country, leaving an abnormally large proportion of aged persons. Nevertheless, after all allowances have been made, the proportion of centennarians in Massachusetts is unexpectedly large, and leads to the belief that its climate and conditions of life are favorable to longevity.

The average age of these 203 centennarians was one hundred and two years, five months, and twenty-five days. One hundred and sixty-five were between one hundred and one hundred and five, thirty-one were from one hundred and five to one hundred and ten, seven were from one hundred and ten to one hundred and fifteen, and one was one hundred and eighteen years of age.

The next fact which claims our attention is that, of these 203

persons, 153 were females and only 50 males—that is, more than three times as many women as men reached the age of one hundred years. This proportion does not vary greatly from that which has been reported in other cases. Thus, in New York city, out of 111 persons dying at the age of ninety years or over, 77 were females and 34 males—a proportion of two and one fourth to one. The Morning Post of London has tabulated all the cases of exceptionally long life which were reported in its columns during the year 1892, and finds that the octogenarians numbered 1,151, of whom 646 were females and 545 males. Above the age of eighty the proportion of females rapidly increases, so that at the age of one hundred or over there are five times as many women as men. Dr. Farr states that of males living at twenty, one in three reaches seventy, one in eight reaches eighty, and one in seventy reaches ninety; while of females living at twenty, one in two and two fifths reaches seventy, one in six and three fourths reaches eighty, and one in forty-nine reaches ninety. Hufeland, in his Art of Prolonging Life, lays down the law that "more women than men become old, but fewer very old." The first part of this law is abundantly sustained by the results obtained in all these cases. As to the latter portion, judging from these figures, it is open to question. In Massachusetts the average age of the 50 males exceeded that of the 153 females by about nine months; but of the eight persons who were over one hundred and ten years two were males and six females—still three to one; and the oldest of all was a female, who had attained the great age of one hundred and eighteen years. This advantage on the part of the female sex—and a considerable advantage we must admit it to be, when we consider that there are nearly five per cent more males born than females, and only one third as many living at the end of a century—is probably due in part to the fact that women as a class have a more favorable environment than men, leading more quiet and regular lives, having fewer bad habits and forms of dissipation to sap their vitality, and being less exposed to death by violence and by accident; and in part to a greater endurance and tenacity of life which are inherent in the female sex.

Considering next the element of *marriage*, we find that 184 had been married one or more times, 14 had never been married, and concerning 5 the facts were not stated. Leaving out of account the latter class, there were thirteen times as many married as unmarried. In the absence of statistics showing the relative proportion of married and unmarried persons in the community at large, it is impossible to determine the proportion of centennarians in each class; but it may be considered as quite certain that the married reach the age of one hundred years in greater

ratio than the unmarried. The average age of the married exceeded that of the unmarried by about fourteen months. This coincides with the results obtained from other sources. So far as I know, all statistics show a smaller mortality rate and a greater longevity among the married than the unmarried. Mr. Darwin urges matrimony as one of the greatest aids to long life, and calls attention to a mass of statistics gathered in France, showing that unmarried men die in far greater proportion than married. Dr. Stark says that bachelorhood ought to be classed with the most unwholesome trades, or with a residence in the most unwholesome districts, so far as danger to life is concerned; and he presents statistics showing that in Scotland the death rate of unmarried men of certain ages was 15 per 1,000 annually, while that of the married men of the same ages was less than half as great. Hufeland says that "all those people who became very old were married more than once, and generally late in life. There is not one instance of a bachelor having attained a great age." Massachusetts statistics present no instance of what may be termed remarkable age, the oldest being one hundred and eighteen, and married; nor do they show whether the individuals mentioned had been married more than once, or late in life. But it is undoubtedly true that the more regular habits and better hygiene of the married, their less degree of exposure, more abundant home comforts, better food in health and better care in sickness and approaching age, together with the moderate and restricted gratification of the sexual appetite—in short, those elements which constitute the environment of the individual—are more favorable to longevity than are the corresponding elements in the unmarried.

Whether this is true in an equal degree of both sexes, however, is more than questionable. Among the Massachusetts centennarians one in eleven of the women had never been married, while among the men the corresponding proportion was only one in twenty-three. Further than this, while there were three times as many women as men among the centennarians as a whole, there were six times as many among the unmarried ones. It would seem to be a fair inference that the effect of celibacy is less fatal to longevity among women than men. Nor is this other than might be expected, when we consider how helpless and dependent is an old man, and how unable to care for himself in the little niceties of life which contribute so largely to health and comfort, and how much less so in all these respects is an old woman.

But it would be a manifest error to conclude that, because the average age of the married exceeds that of the unmarried, therefore this excess of longevity is due to the married state, unless it can first be shown that the individuals composing the two classes

were originally in the enjoyment of the same degree of health and soundness of constitution; whereas, it is an indisputable fact those persons entering the married state are, as a whole, more robust and enduring, and hence have a greater natural expectation of life, than those who remain single; and it is also evident that repeated marriages, and especially marriages late in life, are indications of a greater than usual degree of vigor and vitality. They are therefore in the nature of an effect, rather than a cause, of extreme longevity.

Coming now to the subject of *nativity*, we find that 85 were native-born, 115 were foreign-born, and of three the birthplace was unknown. The average age of the native-born was one hundred and two years and twenty-seven days; and of the foreign-born one hundred and two years, nine months, and eleven days. Again, statistics are lacking to determine the relative number of natives and foreigners in the State as a whole. But as it can hardly be supposed that the foreign outnumbers the native population, these figures would seem to show an advantage on the part of the foreign-born, both in average age and in proportionate number of centennarians. This may be partially explained on the ground that the immigrants who came to this country from fifty to one hundred years ago, when the country was comparatively new and unsettled, would naturally be persons of more than the average vigor and endurance. Pioneers are of necessity a hardy race. The weak and sickly remain quietly at home, while the strong and hardy venture out into a new country and new conditions.

It must not be forgotten also that there is a source of possible fallacy in the ages given. It is proverbially difficult to obtain the exact age of ignorant persons, the tendency being more and more, as years advance, to exaggerate the real age. When to this is added the element of foreign birth, rendering a reference to birth records impossible, it is easy to see that there is a great liability that the ages given by the foreigners as a class were considerably in excess of the true ages.

Among the foreign-born the Irish carry off the palm as to numbers in the list of centennarians, as they undoubtedly do in the general population, furnishing 93 out of 115. Their average age exceeds that of the natives by about eight months, while it is exceeded by the other foreigners as a class by about four months.

As to color, 197 were white, with an average age of one hundred and two years, four months, and twenty-four days; and six were colored, with an average age of one hundred and five years, three months, and twenty-four days; while three of the six colored were over one hundred and ten years of age.

Now, it is an opinion generally held, and I think capable of

proof, that the death rate among these two classes, the Irish and the negroes, is much higher than that of the general population. I have not at hand statistics which will conclusively prove this fact, and will only quote the tables prepared by General Walker, based upon the United States census of 1870, in which he shows that while the Irish constituted three hundred and thirty-three per thousand of the foreign population, they contributed four hundred and ten to every thousand foreign-born decedents, thereby largely exceeding their due proportion.

If we accept the opinion alluded to as a fact, we are brought face to face with the paradoxical condition of a large proportion of persons reaching extreme longevity among classes noted for a low average longevity. How to account for this apparent anomaly is a question of interest. But one explanation suggests itself to me, and this I believe to be, in the main, the true one—namely, that the centennarians of the classes named owe their great age to favorable heredity, a natural life-force and power of endurance transmitted to them by their ancestors, which enabled them to withstand or overcome the unfavorable environment which carried off a large proportion of their respective races; while, on the other hand, the admittedly higher average longevity of the native whites is to be accounted for by their more favorable surroundings and mode of life, better hygiene in health and care when sick, whereby the vitality of the weak, the sickly, and the young is conserved, and many years of life are added to the average. If this explanation be accepted as the correct one, it suggests the law, which is also warranted by a wider observation, that *extreme individual longevity depends chiefly upon favorable heredity, while a high average longevity is promoted mainly by a favorable environment.*

As the result of his studies of the native calendar of Central America and New Mexico, with special reference to linguistics and symbolism, Dr. D. G. Brinton believes that the system of the peoples to whom it appertained was in a certain sense philosophic; that it grew out of ripe meditation on the agencies which direct and govern life; and that it was merely veiled—not smothered—in the symbolism which has been transmitted to us, and which they found it convenient to throw around it, in presenting it to the unlearned. The twenty potencies or agencies, fixed at that number for a reason which the author determines, follow each other in the sequence in which they were believed to exert their influence on the life or existence, not of man only, but of things and of the universe itself. This opinion exerted a strong constructive and directive influence on the national myths, rites, and symbolism, extending to architecture and ornament, to details of government, and to the every-day incidents and customs of national and domestic life. In all of these we perceive a constant recurrence of the signs and their correspondent numbers, drawn from the composite relations of twenty to thirteen.

THE HALF-BLOOD INDIAN.

AN ANTHROPOMETRIC STUDY.

By FRANZ BOAS.*

THERE are few countries in which the effects of intermixture of races and of change of environment upon the physical characteristics of man can be studied as advantageously as in America, where a process of slow amalgamation between three distinct races is taking place. Migration and intermarriage have been a fruitful source of intermixture in the Old World, and have had the effect of effacing strong contrasts in adjoining countries. While the contrasts between European, negro, and Mongol are striking, their territories are connected by broad stretches of land which are occupied by intermediate types. For this reason there are only few places in the Old World in which the component elements of a mixed race can be traced to their sources by historical methods. In America, on the other hand, we have a native race which, although far from being uniform in itself, offers a marked contrast to all other races. Its affiliations are closest toward the races of Eastern Asia, remotest to the European and negro races. Extensive intermixture with these foreign races has commenced in recent times. Furthermore, the European and African have been transferred to new surroundings on this continent, and have produced a numerous hybrid race, the history of which can also be traced with considerable accuracy. We find, therefore, two races in new surroundings and three hybrid races which offer a promising subject for investigation: the Indian-white, the Indian-negro, and the negro-white. The following study is devoted to a comparison of the Indian race with the Indian-white hybrid race.

It is generally supposed that hybrid races show a decrease in fertility, and are therefore not likely to survive. This view is not borne out by statistics of the number of children of Indian women and of half-blood women. The average number of children of five hundred and seventy-seven Indian women and of one hundred and forty-one half-blood women more than forty years old is 5·9 children for the former and 7·9 children for the latter. It is instructive to compare the number of children for each woman in the two groups. While about ten per cent of the Indian

* The material for this study was collected for the Department of Ethnology of the World's Columbian Exposition. Prof. F. W. Putnam, chief of the department, organized a Section of Physical Anthropology, in charge of the writer. It was one of the objects of this section to collect anthropometric material illustrating the racial characteristics of the North American Indians.

women have no children, only 3·5 per cent of the half bloods are childless. The proportionate number of half bloods who have one, two, three, four, or five children is smaller than the corresponding number of Indian women, while many more half-blood women than full-blood women have had from six to thirteen children. This distribution is shown clearly in Fig. 1, which

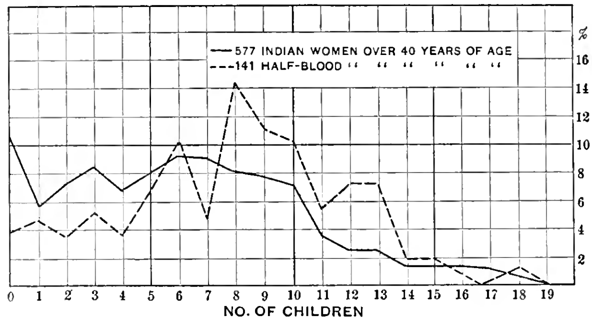

Fig. 1.—Number of Children of Indian Women and of Half-blood Women.

represents how many among each one hundred women have a certain number of children. The facts disclosed by this tabulation show that the mixed race is more fertile than the pure stock. This can not be explained by a difference of social environment, as both groups live practically under the same conditions. It also appears that the small increase of the Indian population is almost entirely due to a high infant mortality, as under better hygienic surroundings an average of nearly six children would result in a rapid increase. It is true, however, that a decrease of infant mortality might result in a decreased birth rate.

Among the Indians of the Pacific coast the infant mortality is also very great, but we find at the same time a still larger proportion of women who bear no children.

It is of some interest to note the average number of children of women of different ages as indicating the growth of families. Among the Indians there is an average interval of four years and a half—as shown in the following table—which, however, must not be confounded with an average interval between births:

Indian	women	20	years of	age	have on the	average	1	child.
"	"	25	"	"	"	"	2	children.
"	"	28	"	"	"	"	3	"
"	"	33	"	"	"	"	4	"
"	"	38	"	"	"	"	5	"

Among the half bloods the interval is shorter, but the number of available observations is insufficient for carrying out the comparison in detail.

The statures of Indians and half bloods show differences which are also in favor of the half bloods. The latter are almost invariably taller than the former, the difference being more pronounced among men than among women. The white parents of the mixed race are mostly of French extraction, and their statures are on an average shorter than those of the Indians. We find, therefore, the rather unexpected result that the offspring exceeds both parental forms in size. This curious phenomenon shows

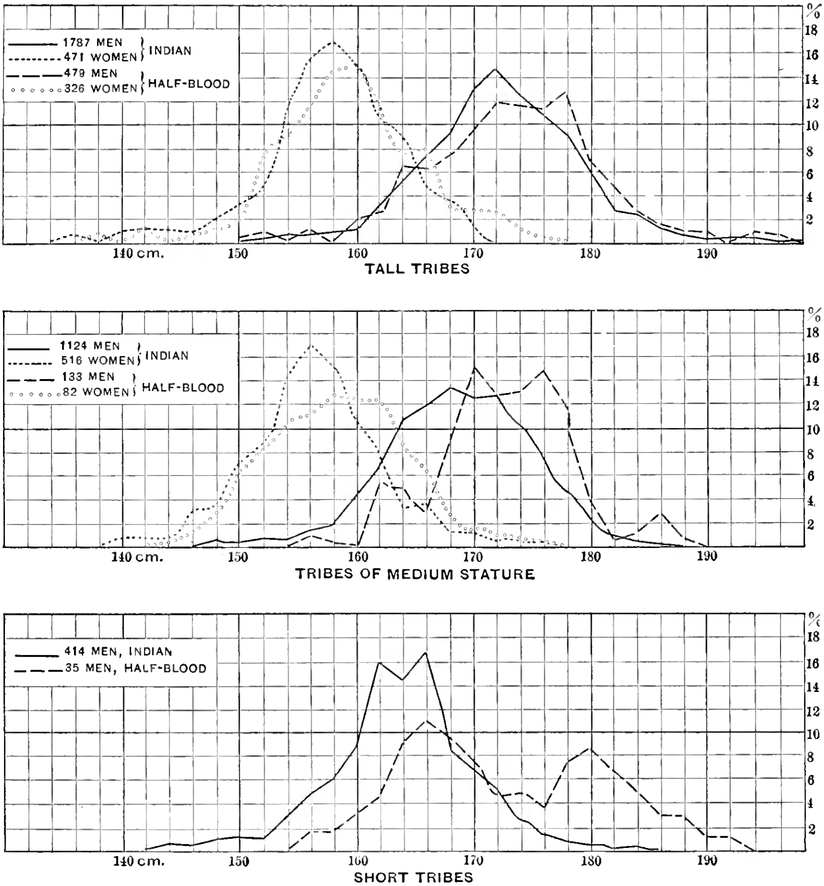

Fig. 2.—Statures of Indians and of Half Bloods.

that size is not inherited in such a manner that the size of the descendant is intermediate between those of the parents, but that size is inherited according to more intricate laws.

From investigations carried on among whites we know that stature increases under more favorable surroundings. As there is no appreciable difference between the social or geographical surroundings of the Indians and of the half bloods, it seems to

follow that the intermixture has a favorable effect upon the race.

The difference in favor of the half blood is a most persistent phenomenon, as may be seen by a glance at the following table:

Differences of Average Statures of Indians and Half Bloods.

Tribes.	Men, centimetres.	Women, centimetres.
Eastern Ojibwa	−0·1	0·0
Omaha	0·0	−0·7
Blackfeet	+0·1	.....
Micmac	+0·6	−0·2
Sioux	+1·0	+0·9
Delaware	+1·6	+0·4
Ottawa	+1·7	+0 4
Cree	+2·0	+2·8
Eastern Cherokee	+3·2	.....
Western Ojibwa	+3·2	+0·7
Chickasaw	+4·5	.....
Choctaw	+7·0	.....
Tribes of medium stature (165 to 169 centimetres)	+3·3	+2·5
Shortest tribes (less than 165 centimetres)	+8·3	+14·8

The last two entries in this table embrace mainly the Indians of the Southwest and of the Pacific coast.

The facts which appear so clearly in the preceding table may be brought out in a different manner by grouping all the Indian tribes according to their statures in three classes: those measuring more than 169 centimetres, or tall tribes; those measuring from 165 to 169 centimetres, or tribes of medium stature; and those measuring less than 165 centimetres, or short tribes. The frequencies of various statures in each of these classes have been plotted in Fig. 2. The horizontal line represents the individual statures from the lowest to the highest. The vertical distance of the curves from any point of the horizontal line shows how many among each one hundred individuals have the stature represented by that particular point. Thus it will be seen that 14·4 per cent of the full-blood men of the tallest class have a stature of 172 centimetres, while only 12·3 per cent of the half blood of the same class have the most frequent stature belonging to them—namely, 178 centimetres. Among the Indian women of the full-blood tribes 16·8 per cent have a stature of 158 centimetres, while only 14·4 per cent of the half bloods have their most frequent stature—namely, 160 centimetres.

This tabulation brings out the peculiarity that the statures of the half bloods are throughout higher than those of the full bloods; and that, at the same time, the most frequent statures are more frequent among the pure race than in the mixed race. This is expressed by the fact that the curves illustrating the dis-

tribution of statures among the half bloods are flatter than those illustrating the same feature among full bloods. This peculiarity may be noticed in all the curves of Fig. 2, with the exception of that of the men of the second group.

The statures near the average of each group are most frequent, and as these values do not occur as often among the half bloods

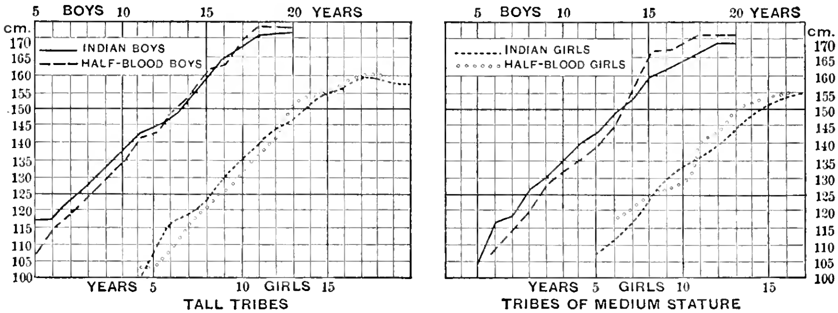

Fig. 3.—Growth of Indian and Half-blood Children.

as among the full bloods, the values which are remote from the average are at the same time relatively more frequent. Thus it becomes apparent that the mixed race is less homogeneous than the Indian race.

Another important phenomenon is revealed by a comparison of the growth of Indians and half bloods (Fig. 3). When the average statures of children of both races are compared, it appears that during the early years of childhood the Indian is taller than the half blood, and that this relation is reversed later on. This is found in both the groups for tall tribes and for tribes

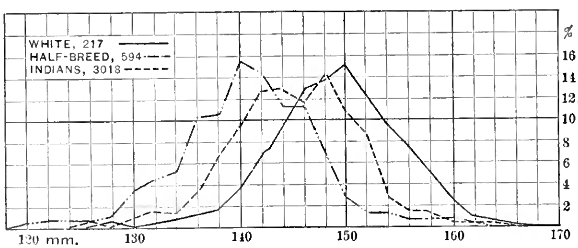

Fig. 4.—Breadth of Face of Indians, Half Bloods, and Whites.

of medium stature. It is to be regretted that this comparison can not be carried on for whites also. The social surroundings of the white child are, however, so entirely different from those of the Indian and of the half-blood children that no satisfactory conclusions can be drawn from a comparison. It is difficult to see why the laws of growth of the Indian and half blood should differ in this manner; why the Indian child at the age of three

years should be taller than the half-blood child, and then develop more slowly than the latter. This peculiarity is most striking in the growth of the tribes of medium stature, as in this case the difference in the statures of adults is so considerable. Unfortunately, we do not know if the same difference prevails at the time of birth; but even if this were the case the difference in the rate of growth would remain mysterious. The various phenomena described here merely emphasize the fact that the effect of intermixture is a most complicated one, and that it acts upon physiological and anatomical qualities alike. We observe in the mixed race that the fertility and the laws of growth are affected, that the variability of the race is increased, and that the resultant stature of the mixed race exceeds that of both parents.

One of the most striking characteristics of the Indian face is its great breadth as compared with that of the whites. It is therefore of peculiar interest to compare this measurement among the full-blood Indian, the half bloods, and the whites. The curves on

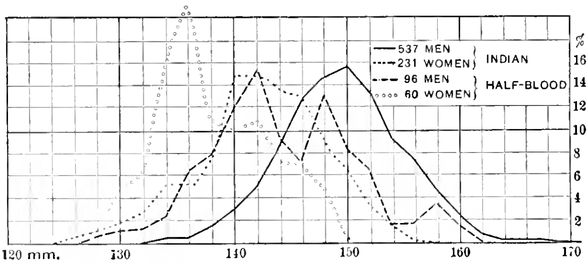

Fig. 5.—Breadth of Face. Sioux.

Fig. 4 show the result of this inquiry. Among adult students of American colleges we find an average breadth of face (between the zygomatic arches) of 140 millimetres, while the average value among Indians is nearly 150 millimetres. The facial measurements of the half bloods are intermediate, the average value being nearer the typical Indian measurement and remote from the white measurement. We find in these curves also the peculiarity observed before—that the half blood is more variable than the pure race. This fact is expressed in the greater flatness of the curve.

It will be noticed that the central portion of the curve illustrating the distribution of the measurements of breadth of face of half bloods is markedly irregular, particularly that it shows a depression in its central portion. This might seem accidental, but it will be seen that in Figs. 5 and 6, where the same measurements for the Sioux and Ojibwas are given, the same phenomenon appears. We see in all these curves that the measurements which are near those of the parental races appear more frequently in the

mixed race than the intermediate measurements. It is true that the number of observed cases may seem rather small to draw this deduction with absolute certainty; but I have noticed that all tabulations of face and head measurements which include more than

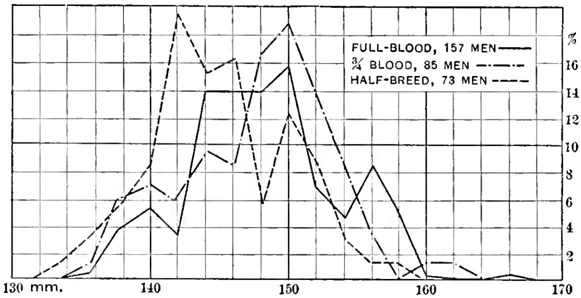

FIG. 6.—BREADTH OF FACE. Eastern Ojibwas.

five hundred individuals give very regular curves except in the case of half bloods, so that I believe I am justified in interpreting the phenomenon illustrated in Fig. 4 as a real one, and that it is not due to the small number of measurements. The correctness of this view can be proved definitely by an appropriate grouping of

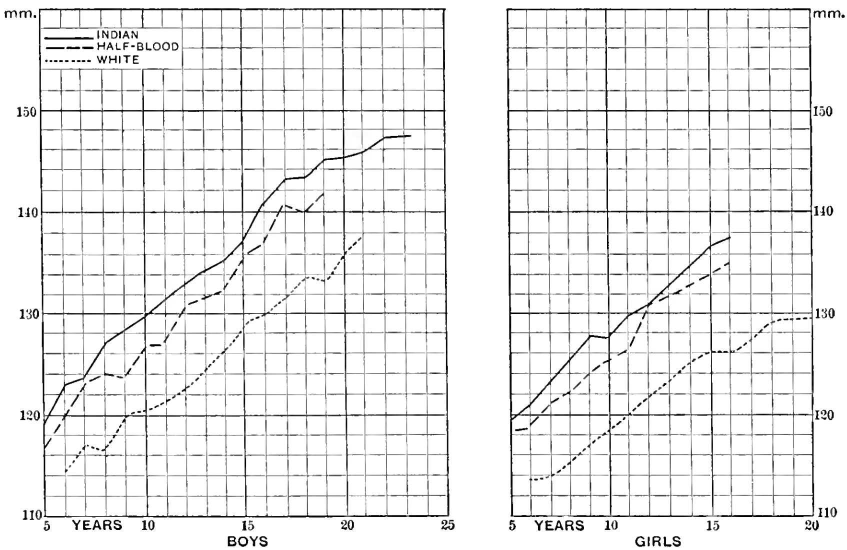

FIG. 7.—BREADTH OF FACE OF INDIAN, HALF-BLOOD, AND WHITE CHILDREN.

the available material according to the following point of view: The breadth of face and the breadth of head of man are closely correlated. The broader the head, the broader the face. Irregularities in the distribution of the measurement of the face will,

therefore, appear more distinctly when individuals are grouped together which have the same breadth of head. I have grouped the material in four classes, with the result that the double maximum of frequency, corresponding to the breadth of face of the parental types, appears more strongly marked in every class. Therefore we must draw the important inference that the face of the offspring has a tendency to reproduce one of the ancestral types—not an intermediate type. The effect of intermixture in this case differs, therefore, fundamentally from the effect observed in the measurements of stature.

When comparing the average breadth of face for Indians, half bloods, and whites, another interesting phenomenon may be seen. The average breadth of face of the half blood stands between that of the Indian and that of the white, but nearer the former. When computing this average from year to year, it is found that the same relation prevails throughout from the fourth year to the adult stage, and in men as well as in women (Fig. 7).

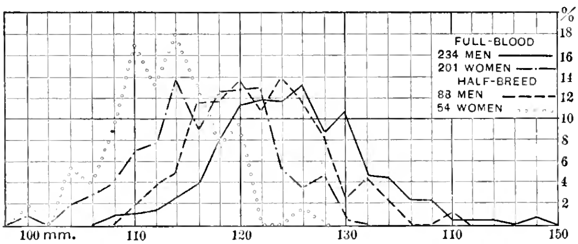

Fig. 8.—Height of Face. Sioux.

The relation of the three groups remains unchanged throughout life. The amount of white and Indian blood in the mixed race is very nearly the same. We find, therefore, the remarkable fact that the Indian type has a stronger influence upon the offspring than the white type. The same fact is expressed in the great frequency of dark hair and of dark eyes among half bloods.

Two reasons may be assigned for this fact. It may be that the dark hair and the wide face are more primitive characteristics of man than the narrow face and light eyes of the whites. Then, it might be said that the characteristics of the Indian are inherited with greater strength because they are older. It must, however, also be considered that half bloods are almost always descendants of Indian mothers and of white fathers, and this may have had an influence upon the race, although there is no proof that children resemble their mothers more than they resemble their fathers.

In carrying out the comparison of breadths of face it would be better to study the curves of distribution for each year, but the

number of observations is insufficient for applying this method. As stated before, the distribution of measurements is such that the parental types are more frequent than the average; for this reason the latter has no real biological significance. It must be

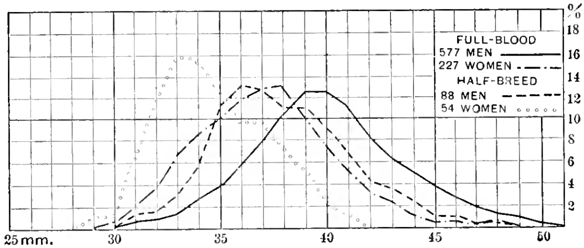

FIG. 9.—BREADTH OF NOSE. Sioux.

considered merely as a convenient index of the general distribution.

Among the eastern Ojibwas I was able to make a classification into three groups: Indians, three-quarter bloods, and half bloods. In this case (Fig. 6) it will be noticed that the influence of the white admixture is very slight in the three-quarter bloods. The maximum frequency of the breadth of face remains at 150 millimetres, and we observe that a small increase in frequency takes place at 140 millimetres.

From the breadth of face I turn to the consideration of the height of face—i. e., the distance from the chin to the suture between the nasal bones and the frontal bone (Fig. 8). This measurement is subject to considerable variations, on account of the difficulty of determining the initial points of the measurement with sufficient accuracy. This accounts for the irregularity

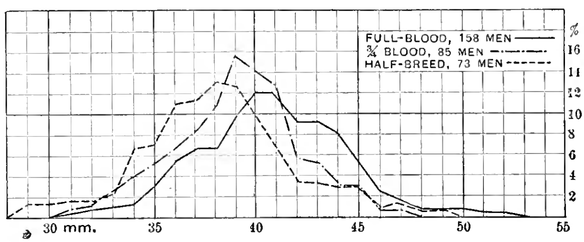

FIG. 10.—BREADTH OF NOSE. Eastern Ojibwas.

of the curves. It appears clearly that the face of the half blood is shorter than that of the white. I am not able to say if this phenomenon is due to a general shortening, or if the nose, the jaw, or the teeth contribute most to this effect. The difference between full blood and half blood is much smaller than in the case of the breadth of face.

The two measurements combined show that the Indian face is considerably larger than the face of the half blood, while the latter is in turn larger than the face of the white. As the head measurements of the tribes which have contributed to these statistics prove that there is no appreciable difference between these races regarding the size of the head, we are led to the conclusion that the Indian face is also relatively larger than that of the half blood and of the white.

Another characteristic difference between Indians and half bloods will be found by comparing the breadth of nose of both races. It is well known that the nostril of the Indian is round, and that it is bordered by thick alæ, while the nostril of the white is elongated and has fine alæ. Unfortunately, there are no measurements of the nose of the white available, but a comparison of the transversal breadths of the nose of Indian and half blood (Fig. 9) makes it clear at once that intermixture has the effect of making the nostril narrower and the alæ thinner,

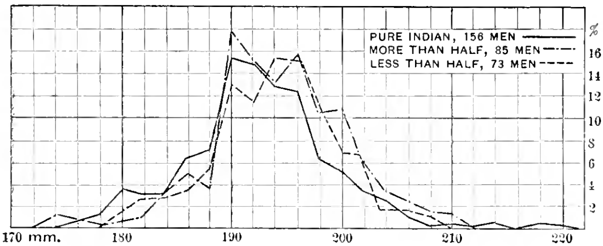

Fig. 11.—Length of Head. Eastern Ojibwas.

thus producing a much narrower nose. It appears at once that the nose of the half-blood man is not wider than that of the full-blood woman. The three-quarter bloods of the Ojibwas (Fig. 10) are found to take an intermediate position between full bloods and half bloods.

We will finally consider the effect of intermixture upon the length of head from the point between the eyebrows (the glabella) to the occiput among a tribe with a head that is shorter than that of the American white. The Ojibwa has a head which measures about 191 millimetres, while that of the white measures about 195 millimetres. A comparison of the three classes (Fig. 11) shows a gradual increase in length from the full blood, through the three-quarter blood, to the half blood.

We find, therefore, that the laws of heredity in the forms of the head and face are uniform, in so far as intermediate forms are produced. I presume, however, that in all these cases the middle forms are not found as frequently as forms resembling the two parental types.

WEST AFRICAN FOLKLORE.

By Colonel A. B. ELLIS.

UNTIL a few years ago it was popularly believed that the negro nations of West Africa were in the unique position of never having produced anything worth recording. They were supposed to have no history, no traditions, and no folklore, and even their religion was said to be something infinitely lower than was found anywhere else, a worship of sticks, stones, or shells, picked up at haphazard, and deified without rhyme or reason. This groveling religion, which was alleged to be significant of the degraded condition in which the West African negro was believed to be, was called fetichism, a word which, while really a corruption of the Portuguese *feitiço*, "amulet" or "charm," was supposed to be a negro word; and several treatises were written to show that, as it was impossible to conceive a lower form of religion, fetichism might therefore be assumed to be the beginning of all religion.

All these extraordinary beliefs, which had no foundation whatever in fact, may be traced to the reports made by those persons who, being engaged in the slave trade, resorted to West Africa in the seventeenth and eighteenth centuries. The great majority of these men had but a very transient acquaintance with West Africa, only remaining on the coast sufficiently long to obtain cargoes of slaves; and consequently it was impossible for them to have any real knowledge of the natives with whom they were brought in contact. Then, as they had no knowledge of African languages, they were dependent for their information upon those negroes who had acquired a smattering of some European language, and in most cases they seem to have completely misunderstood what their informants doubtless intended to convey. In other cases the slave-traders no doubt drew upon their imaginations, or exaggerated what they had seen; for if they could show that the negro was a mere brutish animal, they palliated to some extent the iniquity of the slave trade; and so his fancied brutishness was persistently brought to the front—at all events toward the end of the last century, when the traffic in slaves had begun to fall into disrepute.

Dr. Theodor Waitz, the distinguished author of Anthropologie der Naturvölker, was the first to express a doubt as to the authenticity of the supposed facts concerning the social condition and religion of the West African negro—which work my long acquaintance with West Africa has enabled me to continue, and in two volumes * I have shown that the religion of the negro, so far

* The Tshi-speaking Peoples of the Gold Coast and The Ewe-speaking Peoples of the Slave Coast.

from being fetichism, is a pure animism, or worship of spirits, differing in no important particular from that of other people on the same plane of civilization. In this paper I propose to dispel another illusion, and show that the negro, like all other races, has his folklore, or popular tales, which are in no wise inferior to those invented by other people. Of course, the Uncle Remus stories of Mr. Joel Chandler Harris are really American-negro versions of West African folklore tales, but in most cases the tales have been so much changed in order to adapt them to the altered conditions of life and the new *locale* that they can now scarcely be called examples of West African folklore.

It is among the Yoruba tribes of the Slave Coast that we find the folklore instinct most fully developed, and their tales may be numbered probably by hundreds. The itinerant story-teller, *akpalo kpatita* ("one who makes a trade of telling fables"), is a well-known character, who wanders from town to town, reciting tales. He is always well received, and is in great demand for social gatherings. He very frequently carries with him a drum, with the rhythm of which he fills up the pauses in the narrative. He strikes a few taps on the drum, to attract attention, and as soon as an audience is gathered he announces, "My *alo* * is about so-and-so," and then commences the recital.

The first and second of the following tales are Yoruba; the third is from the Ewe tribes, who inhabit the western portion of the Slave Coast, and among whom Dahomi is the one best known to Europeans; while the fourth is from the Tshi tribes of the Gold Coast, among whom are the Ashantis and Fantis. In each case the exact English equivalent of the native version has been given, and none of the stories have been in the least "touched up."

I. THE GOBLIN'S GIFT.

My *alo* is about a woman whose little girl made palm oil.†

One day, when she had made palm oil, she took it to the market to sell.

She stayed in the market selling her palm oil until it was quite dark. And when it was dark, a goblin ‡ came to her to buy palm oil, and paid her with cowries.#

When the little girl counted the cowries she found that there was one short. And she asked the goblin for the cowry that was wanting.

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* *Alo*, a tale, fable.

† Palm oil, which is made from the nut of the oil palm (*Elais guiniensis*), is largely used in native cookery, and is one of the chief articles of commerce.

‡ *Iwin*, goblin, spirit, or ghost.

The cowry shell is the currency of the Slave Coast.

The goblin said that he had no more cowries, and the little girl began crying, "My mother will beat me if I go home with a cowry short."

The goblin walked away, and the little girl walked after him.

"Go away," said the goblin; "turn back, for no one can enter the country in which I live."

"No," said the little girl; "wherever you go, I will follow, until you pay me my cowry."

So the little girl followed, followed a long, long way, till they came to the country where the people stand on their heads in their mortars, and pound yams with their heads.*

Then they went on again a long way, till they came to a river of filth. And the goblin sang:

"O young palm-oil seller,
You must now turn back."

And the girl sang:

"Save I get my cowry,
I'll not leave your track."

Then the goblin sang again:

"O young palm-oil seller,
Soon will lead this track
To the bloody river,
Then you must turn back."

And she,

"I will not turn back."

And he,

"See yon gloomy forest."

And she,

"I will not turn back."

And he,

"See yon craggy mountain."

And she,

"I will not turn back;
Save I get my cowry,
I'll not leave your track."

Then they walked on again, a long, long way; and at last they arrived at the land of dead people.

The goblin gave the little girl some palm nuts with which to make palm oil, and said to her, "Eat the palm oil yourself, and give me the *ha-ha*." †

But when the palm oil was made the little girl gave it to the goblin and ate the *ha-ha* herself. And the goblin said, "Very well."

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* Yams are pounded into a sticky mass with a long wooden pestle, in a wooden mortar, hollowed out of a section of a trunk of a tree.

† *Ha-ha*, the stringy remnant of the pulp of the palm nut after the oil has been expressed.

By and by the goblin gave a banana to the little girl, and said, "Eat this banana, and give me the skin." But the little girl pealed the banana and gave it to the goblin, and ate the skin herself.

Then the goblin said to the little girl: "Go and pick three *ados*.* Do not pick the *ados* which cry, 'Pick me, pick me, pick me'; but pick those that say nothing, and then return to your home. When you are half-way back, break one *ado;* break another when you are at the house door, and the third when you are inside the house." And the little girl said, "Very well."

She picked the *ados* as she was told, and returned home.

When she was half-way home she broke one *ado*, and behold, many slaves and horses appeared and followed her.

When she was at the house door the little girl broke the second *ado*, and behold, many creatures appeared, sheep and goats and fowls, more than two hundred, and followed her.

Then, when she had entered the house, the little girl broke the last *ado*, and at once the house was filled to overflowing with cowries, which poured out of the doors and windows.

The mother of the little girl took twenty country cloths, twenty strings of valuable beads, twenty sheep and goats, and twenty fowls,† and went to make a present to the *iyale*.‡

The *iyale* asked whence all these things came, and when she had been told she refused to accept them. She said she would send her own child to do the same, and that she could easily get as much.#

Then the *iyale* made palm oil and gave it to her own little girl, and told her to go and sell it in the market.

The little girl went to the market. The goblin came, bought palm oil of her, and paid her with cowries. He gave the proper number of cowries, but the little girl hid one and pretended that he had not given her enough.

"What am I to do?" said the goblin. "I have no more cowries."

"Oh!" said the little girl, "I will follow you to your house, and then you can pay me." And the goblin said, "Very well."

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* The *ado* is a small calabash, commonly used for keeping medicinal powders in.

† The Yorubas reckon by scores and two hundreds—i. e., ten scores.

‡ In polygamous households the chief wife, who rules the others, is called the *iyale*, "mistress of the house." The mother of the little girl was one of the inferior wives, called *iya-wo*, "mistress of trade," because they usually sell in the markets.

\# From the European point of view this would appear to be a good trait on the part of the *iyale*, for the inference would be that she did not wish to deprive the subordinate wife of so much property, but that would not be the construction a native would put on it. To the native mind a person only refuses a present when he is nurturing rancor against the donor, and to refuse a gift is regarded as a sign of enmity.

Then the two walked together, and presently the goblin began singing, as he had done the first time. He sang:

"O young palm-oil seller,
You must now turn back."

And the little girl sang,

"I will not turn back."

And the goblin,

"You must leave the track."

And the girl,

"I will not turn back."

Then the goblin said, "Very well, come along." And they walked on till they reached the land of dead people.

The goblin gave the little girl some palm nuts and told her to make palm oil. He said, "When the palm oil is made, eat it yourself, and bring me the *ha-ha*." And the little girl ate the palm oil and brought the *ha-ha* to the goblin. And the goblin said, "Very well."

Then the goblin gave a banana to the little girl and told her to peel it. He said, "Eat the banana yourself, and bring me the skin." And the little girl ate the banana and carried the skin to the goblin.

Then the goblin said: "Go and pick three *ados*. Do not pick those which cry, 'Pick me, pick me, pick me,' but pick those which say nothing."

The little girl went. She found *ados* which said nothing, and she left them alone. She found others which cried, "Pick me, pick me, pick me," and she picked three of them.

Then the goblin said to her: "When you are half-way home, break one *ado;* when you are at the door, break another; and break the third when you are inside the house."

Half-way home the little girl broke one *ado,* and behold, numbers of lions and leopards and hyenas and snakes appeared. They ran after her, and harassed her, and bit her, till she reached the door of the house.

Then she broke the second *ado,* and behold more ferocious animals came upon her, and bit and tore her at the door.

The door was shut, and there was only a deaf man in the house. The little girl called to the deaf man to open the door, but he heard her not. And there, upon the threshold, the wild beasts killed the little girl.

II. THE MAIDEN WHO ALWAYS REFUSED.

My *alo* is about a beautiful maiden.

A man, his wife, and daughter lived in one house, in a certain town. And the girl grew up; she grew up very beautiful, and her father and mother were rich.

All the young men who saw her wanted her, and many of them sent presents to her father and mother, asking for her in marriage; but the maiden said she did not wish to marry.

So, whenever men came to ask for her, the maiden continued to refuse. She said, "My figure is good, my face is good, my skin is good,* therefore I shall not marry till I find a young man who pleases me."

So many young men came that at last the father and mother were tired of urging their daughter to marry, and they said to her: "Very well, choose for yourself; we will have nothing more to do with it."

And the maiden said: "Be not angry, O my father and O my mother! I am handsome, and I will only marry with one who is handsome. If I meet such a one in the town, I will make such and such signs to you when he walks with me to the door."

Now the leopard, living in his own place in the bush, heard this; and he turned himself into a handsome young man.†

He came into the town, and all the young girls turned their eyes after him, for he was good to look at, and he wore a silken cloth.

He walked through the town, holding in his hand a *duru*,‡ and he played on it a tune that was melancholy and sweet.

Now, just at this time the beautiful maiden had come out of her house, and as she walked along the street she saw the handsome young man playing on the *duru*. And the sounds of the tune he was playing went into her heart, and his appearance pleased her, and she loved him.

So she stood still in the street, looking upon the young man, who came nearer and nearer. And when the young man had reached her, he said, "Beautiful maiden, I am from a far country, to which the fame of your beauty has penetrated, and I have come hither to ask you to marry me, if you will so please."

And the maiden smiled and was glad. But she turned her eyes to the ground, and said to the young man: "O handsome stranger, is it the custom in your country thus to ask maidens to marry? My father and mother are here, near by, and with them lies the giving."

Then she led the way to the house of her parents, and the young man followed. And when she was at the door of the house she made the signs to her father and mother so that they might know that this was a young man whom she was willing to marry.

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* A smooth, glossy skin is considered a great beauty.

† In the Tshi variant of this story it is a python who personates a young man.

‡ The native guitar, called *sanku* on the Gold Coast. It has four, six, or eight strings, and is tuned in the diatonic minor scale, C, D, E flat, F, G, A, B, C.

The young man entered the house, still playing on his *duru*, and the sound of the music charmed the hearts of the old people, and his appearance pleased them, and they were glad.

And after greetings made, the young man said, "My father and my mother, I am from a far country, to which the fame of your daughter's beauty has penetrated, and I have come hither to ask you to give her to me in marriage."

And the old people said: "This, our daughter, has been many times asked in marriage, and has always refused;* therefore we said to her, 'Choose for yourself'; and now, if she says 'Yes,' we will not say 'No.'"

Then the young man took the maiden by the hand and looked into her eyes, and said, "Beautiful maiden, do you agree that we shall be married together?"

And the maiden smiled, but she turned her head to one side, and said softly, "Yes, handsome young man, I agree." And then she ran and hid in another room, for she felt bashful.

Then the young man thanked the old people, and he paid the head money and the head rum,† and gave many silk cloths for the bride, and the same evening they were married.

Next morning the young man said to the old people that he would now take his wife and return to his own country.

The old people felt sad at their child leaving them so soon, but they did not refuse. They gave her presents, and goats, and sheep, and fowls, and two female slaves, one that her father gave and one that her mother gave.

Then the father gave a word of advice to his child and the mother embraced her. They walked out on the road a little way with her, and then they turned back.

Then the young woman and her husband went on. They took a road that led into the forest, and the young man walked holding his wife's hand.

Then the husband led the way along a narrow and rough path, and the forest grew darker and denser, and the wife began to be afraid, for she saw she was going away from the cultivated lands into the haunts of wild beasts.

Presently, when they were in the thick wood, the husband said, "Wife, I am hungry."

And the young woman said: "How can I cook anything in

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* Parents can not compel a daughter to accept an unwelcome suitor, but if a girl persists in refusing eligible offers without sufficient reason they can, if they choose, refuse to maintain her any longer.

† Contracts of marriage are made by paying a certain sum, called "head money," and the payment of this sum is the only ceremony. "Head rum" is the term given to the refreshments which are provided for the marriage feast by the bridegroom.

this narrow place, husband? Wait at least until we reach the next village."

And the husband replied, "You need never cook for me, wife, for I eat my food raw."

Then the young woman was frightened, and began to have doubts about the man she had married. But she told the two slaves to put the calabashes down on the ground and asked her husband if he would eat some yam.

And he said, "I am not one who eats roots," and he took the fowls and ate them raw. He ate them all.

Then they went again along the path, farther into the forest, and presently the husband said again: "Wife, I am hungry. Is there anything to eat?"

The young woman was very much frightened; she did not know what to do, but she said, "Here are some sheep," and the husband took the sheep and ate them all up.

Then they went again on their way, and, after a little, the husband said, "Wife, I am hungry." And she said, "There are goats." And he took the goats and ate them.

After he had eaten the goats they went on once more, and soon the husband said again: "Wife, I am hungry. Give me something to eat."

And she said: "Is not everything finished? Have you not eaten the fowls and the sheep and the goats that my dear parents gave me? And now there is nothing more in my hand."

And he said, "All is not finished, for there are these two persons."

Then the young woman wept, she wept bitterly, and she cried, "Take them, then, and eat them, if it must be so."

Now, in order to bring down this flesh so that he might eat it, the husband had to turn himself back into a leopard. And he sprang upon the two slaves, and tore them and killed them, and ate them up.

When he had finished eating he again turned himself into a young man, and took his wife's hand and led her along the path. She wished to run away, but she did not know the way out of the forest, and fear had weakened her legs.

Presently the husband said again: "Wife, I am hungry. Give me something to eat."

Then the young woman threw herself on the ground and wept and lamented, for everything was finished, and there was nothing more to give him.

And the husband came and stood near her, looking sideways, and she was plump and soft, and he began to lick his lips.

Now, there was a hunter in the bush near by, and he heard

the lamentations of the young woman, and he crept up close and lay hid.

Then the husband said again, "I am hungry," and the wife sobbed and wept, but said nothing, for everything was finished.

Then the husband turned himself back into a leopard, and crouched down to spring upon her. He was just making a leap, when the hunter fired his gun, "Bang!" and he fell down. He was dead.

Then the hunter came out of the bushes. He spoke to the young woman and lifted her up. He cut off the tail of the leopard, and took the young woman to his house, where he made her his wife.

And this is the way of young maidens. The young men come to ask, and the young maidens refuse. They refuse again, again, and again, until at last the wild beasts turn themselves into men and come and carry them off.

III. WHY THE HARE HAS LONG EARS.

This is a story of the hare and the other animals.

The dry weather was parching up the earth into hardness. There was no dew, and even the denizens of the water suffered from thirst. Soon famine came, and the animals, having nothing to eat, assembled in council.

"What shall we do," said they, "to keep ourselves from dying of thirst?" And they deliberated a long time.

At last it was decided that each animal should cut off the tips of his ears and extract the fat from them. Then all the fat would be collected and sold, and with the money they would get for the fat they would buy a hoe and dig a well, so as to get some water.

And all cried: "It is well. Let us cut off the tips of our ears."

They did so, but when it came to the turn of the hare to cut off his ears he refused, and that is why his ears are so long.

The other animals were astonished at this conduct, but they said nothing. They took up the ear-tips, extracted the fat, went and sold all, and bought a hoe with the money.

They brought back the hoe and began to dig a well in the dry bed of a lagoon. "Ha! here is water at last. Now we can slake our thirst a little."

The hare was not there, but, when the sun was in the middle of the sky, he took a calabash and went toward the well.

As he walked along, the calabash dragged on the ground and made a great noise. It said: "Chan-gañ-gañ-gañ; chan-gañ-gañ-gañ!" *

* The circumflex denotes a highly nasal sound.

The animals who were watching by the lagoon heard this noise and were frightened. They asked each other, "What is it?" Then, as the noise kept coming nearer, they ran away.

Reaching home, they said there was something terrible at the lagoon, that had put to flight the watchers by the well.

When all the animals by the lagoon had gone, the hare drew up water without interference. Then he went down into the well and bathed, so that the water was muddied.

When the next day came all the animals ran to take water, and they found it muddied.

"Oh!" they cried, "who has spoiled our well?"

Saying this, they went and got an image. They made bird-lime and smeared it over the image. Then they set it up by the well.

Then, when the sun was again in the middle of the sky, all the animals went and hid in the bush near the well.

The hare came. His calabash cried: "Chan-gañ-gañ-gañ; chan-gañ-gañ-gañ!" He approached the image. He never suspected that all the animals were hidden in the bush.

The hare saluted the image, but the image said nothing. He saluted again, and still the image said nothing.

"Take care," said the hare, "or I will give you a slap."

He gave a slap, and his right hand remained fixed in the bird-lime. He slapped with his left hand, and that remained fixed also.

"Oh! oh!" cried he, "let us kick with our feet."

He kicked with his feet. The feet remained fixed, and the hare could not get away.

Then the animals ran out of the bush and came to see the hare and his calabash.

"Shame, shame, O hare!" they cried together. "Did you not agree with us to cut off the tips of your ears, and when it came to your turn to do so, did you not refuse? What! you refused, and yet you come to muddy our water?"

They took whips, they fell upon the hare and they beat him. They beat him so that they nearly killed him.

"We ought to kill you, accursed hare!" they said. "But no—run."

They let him go, and the hare fled. Since then he does not leave the grass.

IV. LEGEND OF THE ORIGIN OF THE SARFU TOTEM CLAN.

There was a man of Chama* whose wife died. He buried her and mourned for her; and one day, in the evening, when he was

* Chama is a native town at the mouth of the river Prah.

walking along the beach toward the village of Aboanu, thinking about his dead wife, he met a strange young woman.

The young woman, who was very handsome, asked him why he walked alone and appeared so sad. He replied: "My wife is dead, and I am living alone. I feel lonely by myself, and there is no one to cook my meals."

The young woman said she felt sorry for him, and the two walked on, conversing together. She spoke kindly, and the man liked her appearance; so before long he asked her to take the place of the deceased, and come home and live with him. She agreed to the proposal, and, returning with the man to his house the same night, became his wife.

They lived together very happily for a time, but when three months had passed the wife grew restless and uneasy. Her husband asked her what was troubling her, but she put him off with excuses, until at last one day, when he had again asked her what was the matter, she said that she was uneasy in mind because she must leave him to go and visit her family.

The husband said, "That need not trouble you, for I will go with you"; but to this she would not consent, saying that alone she had come to him and alone she must go away.

Then the husband declared that he *would* go with her, and, as she still continued to refuse, he asked her to tell him her reason. For a long time she would not tell him, but at last he pressed her so much that she said, "I will not allow you to go with me, because you would laugh at me when we returned."

This answer much puzzled the husband. He asked, "Why should I laugh at you?" but she would not say why until he had sworn a great oath that he would never allude to what she was about to tell him. She then said: "You think I am a woman, but I am a fish. My family are fishes, and my home lies in the sea. If you still wish to accompany me, count the breakers as they fall upon the shore, and dive with me under the third one."

As the third breaker dashed upon the beach she threw herself under it, and, her husband following her, they both passed under the water, and arrived at the spot where her family dwelt. There the wife was joyfully received by her relations; she told her tale and introduced her companion as her husband.

The fish family made the man very welcome, and a house was put in order for him, outside which he was strictly enjoined not to venture; but they did not give him any reason for this.

The man complied with the request for some days, and then, one night, being tired of staying in the house, and seeing some young fishes at play, he went out to look at them more closely. He had scarcely left the house when all his wife's family came

round him, begging him to return, and, though he could not understand why they were so anxious, he returned.

Three days later, seeing the young fishes again at play, he a second time left the house to go and look at them. Now, since he had taken up his abode in the sea, he had acquired some of the peculiarities of fishes, among others the emission of a phosphorescent light by night; and, coming too near the surface of the water, he was seen by some fishermen in a canoe, who immediately speared him, thinking him to be an unusually fine fish. He cried out for help, and his wife's relations hastened to his assistance. They endeavored to drag him down to the bottom of the sea, but, finding that all their efforts were unavailing, and that the fishermen were still pulling him up, they begged a shark that was swimming by to bite through the fishing line that was fastened to the spear. The shark immediately complied, and the man was once more at liberty. He was taken back to the house, the spear was drawn out of his body, and by means of dressings which were applied the wound soon became healed.

This narrow escape had much frightened his wife's relations, and as soon as the man had recovered they told him that he could not stay there any longer, lest some other accident should befall him through his imprudence. Therefore they sent him back to the land with his wife, giving him as a parting gift the spear, which they specially charged him to keep carefully concealed.

When they returned to the shore the two went back to their former abode, and the man carefully hid the spear in the thatch of the roof. The house in which they lived formed one side of a central court, and other families lived in the houses on the three other sides. In one of these houses was the owner of the whole, and some years after the return of the husband and wife from the sea he determined to put new thatch on all the houses.

After he had got the grass all ready for rethatching, he began taking the thatch off the house in which the man and his fish wife lived, and had hardly taken off three armfuls before he discovered the spear, which the man had forgotten all about. Directly the house-owner saw the spear, he knew it by the marks on it, and said, "This is mine." He said that he had lost it one night when out fishing; that he had speared a large fish with it, which had broken the line and escaped. "How did you get it?" he asked the husband.

The husband pretended not to hear, but the house-owner repeated the question. Then the husband said he did not know the spear was there, but the house-owner said he did not believe him. He called him a thief, and said he would bring a palaver before the chief, because he had stolen the spear. Then the man was obliged to tell all to clear himself, and the house-owner was satis-

fied, and no more was said; but all the town now knew that the woman was a fish woman.

Nothing bad happened from this for some time, though the husband had broken his great oath never to mention that his wife and her family were fishes; but one day a second wife whom the man had taken quarreled with the first wife—as wives will quarrel—and she taunted the first wife with being a fish, and laughed at her. The first wife was so much hurt at this that she made up her mind to go back to her family in the sea and become a fish once more. She went to her husband and said: "Twice have you done wrong: first, in refusing to let me go alone to visit my family; and secondly, in breaking your great oath and revealing my secret, which you swore to keep. I can no longer live in a place where I and my children will be laughed at and put to shame. I will return to my home."

Her husband endeavored to pacify her, but in vain, for she would not be pacified. He said he would send away the second wife, but still she was not satisfied. He begged and entreated her to stop, but it was all of no use. Then he tried to hold her and keep her by force, but she broke away from him, and running down to the seashore, called to him a last good-by, and plunged into the sea with her youngest child in her arms. After that she was never seen again. Her two elder children remained with their father, and from them is descended the *Sarfu-ni-nam* * clan, none of whom may ever eat *sarfu*, for the fish woman was, when in the sea, a fish of that kind.

Far from finding fault with the mistakes in science which we observe in the works of the early Christian exegetists, the Rev. John A. Zahm, of the University of Notre Dame, maintains that "we should rather be surprised that the errors are so few. They were certainly not more numerous, nor more serious, than those found in the works of the ablest of the professional exponents of the profane science of the period. It were foolish to expect them to know more about geography than Eratosthenes and Strabo and Pomponius Mela, who had made a life study of the subject; or to demand of them a more accurate knowledge of astronomy than was possessed by Hipparchus or Ptolemy; or to suppose that they should have a more precise and a more extended acquaintance with physics and natural history than had Aristotle or Pliny. Such an exaction would be the height of unreason. As well might we find fault with them for not being so well versed in physics as Ampère or Maxwell, or reproach them for knowing less of astronomy than Leverrier or Father Secchi, and less of geography than Humboldt, Malte-Brun, or Carl Ritter—men whose science was based on the experiments and observations of thousands of investigators, and on the accumulated knowledge of well-nigh twenty centuries."

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* *Sarfu-ni-nam*, "No sarfu flesh"; literally, "Not to have sarfu flesh." The *sarfu* is a kind of horse mackerel.

BARBERRIES: A STUDY OF USES AND ORIGINS.

By FREDERICK LE ROY SARGENT.

II.

WHILE the vegetative organs of barberries exhibit, as we have seen, an abundant variety of form and many degrees of differentiation, the reproductive organs are, on the contrary, so very similar throughout the group that what we may find to be true of a single example, such as *Berberis vulgaris*, will apply very generally to all the other species.

In the flowers (Figs. 2 and 3) there is traceable in almost every feature some relation to the visits of insects. Thus the conspicuousness gained by the yellow color * of every part, enhanced by the clustering of the flowers and supplemented by their sweet perfumes † attractively advertise, the abundant nectar which visitors find provided for them through the activity of the twelve orange glands (Fig. 3, N). In time of rain these sweets are protected by the pendent or nodding attitude of the flowers. On the arrival of an insect the movements by which it obtains a sip of the nectar are turned to account in a way to secure an advantageous transfer of the pollen from anther to stigma.

It has long been known that the stamens are so sensitive that at the slightest touch on the filament there is a quick inward bending of the organ which brings the anther with its exposed pollen to the center of the flower. Subsequently the stamen regains its original position, and will now respond to another touch as before. Sprengel in whose classic work ‡ were first revealed some of Nature's most cherished secrets, considered this to be an arrangement whereby insect visitors brought about the self-pollination of the flower, thus making possible the setting of seeds. But later experiments have shown that while Sprengel was entirely right in supposing insect visits to be of the utmost importance in securing fertilization, nevertheless the barberry is no exception to the general rule announced by Darwin, that flowers which attract insects gain from their visits the advantages which come from the transference of the pollen of one flower

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* As berberine is reported to occur in the flowers (Huseman u. Hilger, Pflanzenstoffe), their color may be considered as due at least in part to the same pigment which is present in the wood and bark.

† According to Kerner (Pflanzenleben, ii, p. 195) this odor is essentially the same as that of white hawthorn flowers, which is known to arise from the presence of trimethylamine—a substance widely distributed in Nature, and curiously enough the cause of the characteristic odor of herring brine.

‡ Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen. Berlin, 1793.

to the stigma of another, the result of such cross-pollination being greater vigor in the offspring. Thus Prof. Halsted * found that barberry flowers from which insects had been carefully excluded produced no fruit (others uncovered on neighboring branches fruiting abundantly), and this in spite of the fact that through jarring or as a result of age the stamens had curved inward as far as they ever could. Microscopical examination showed a considerable quantity of pollen to have been deposited among the viscid hairs which form a ring about the top of the pistil (see Fig. 3, H), but none whatever upon the cushion-like summit which was found to be the only part that served as stigma.

Barberry blossoms are great favorites among the insects. Few of our June flowers gather about them a larger number of bees, hornets, flies, butterflies, and beetles. The smaller bees and certain flies are especially abundant.

There is some reason to believe that the intense color of the glands may serve as a guide to the insect, directing it at once without loss of time to the nectar which collects in little hollows between the bases of the filaments and the glands, where it is held by capillary attraction. An insect in thrusting its proboscis into a nectar cavity must touch the base of two filaments, whereupon both stamens suddenly bend inward and strike the insect's head. Now, Müller † calls attention to the fact that while large insects such as bumblebees pay no attention to this, but continue to make the circuit of the flower, smaller ones, like the hive bee, appear to be somewhat startled by this performance and fly away at once to another barberry flower. But the insect carries with it some pollen upon one side of its head, and if in the next flower this comes into the same relative position as before, more pollen will be added on the same part; but if, on the other hand, the flower is approached from the other side, then the pollen already collected will be deposited upon the stigma, while at the same time a new supply of pollen is being received which may in turn be carried to still another flower. As the smaller insects are the more common visitors, cross-pollination, which is so much the best for offspring, must therefore be the most usual result.

This sensitiveness of the stamens is exhibited by all the species of *Berberis* so far as known, but is not found in other members of the family, although a somewhat similar irritability of stamens has been observed in certain of the *Portulacaceæ*, *Tiliaceæ*, *Cistaceæ*, and *Compositæ*. The strikingly animal-like nature of the movement is well shown by the following facts: A chemical stimulus, such as ammonia gas, will induce contraction as effectually as a mechanical stimulus. The presence of oxygen

* Botanical Gazette, August, 1887, p. 201.

† The Fertilization of Flowers, p. 91.

and a suitable temperature are necessary conditions. Repeated stimulation at short intervals fatigues the organ, making it less and less responsive, until finally all signs of sensitiveness disappear, to return only after a period of rest. Certain chemical substances which are known to abolish or suspend the contractility of animal protoplasm have been found to affect in a corresponding manner the movements of barberry stamens. Thus nicotine, alcohol, and the mineral acids destroy all power of movement. A one-per-cent solution of morphine is similarly active, while curare, the powerful nerve poison which leaves the contractility of muscle unaffected, is found to exert no influence upon the stamens of *Berberis*. The effect of arsenic and corrosive sublimate is to render the filaments rigid and brittle, while if poisoned with prussic acid or belladonna they become relaxed and flaccid. By exposure for a short time to the vapor of chloroform or ether the

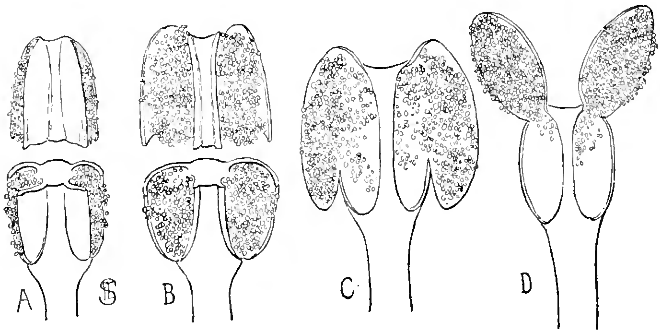

Fig. 13.—Series of anthers connecting the primitive form with that having valvular dehiscence: A, *Podophyllum emodi;* B, *Podophyllum peltatum;* C, hypothetical transition form; D, the barberry form. All somewhat diagrammatic.

power of movement is suspended, but may return after removal from the influence of the anæsthetic.

Moreover, experiment shows that the part of the filament which contracts is not necessarily the part touched—that is to say, there is a transmission of stimulus from cell to cell. So long as it was believed that the contents of neighboring plant cells were always completely separated by an imperforate wall, no satisfactory explanation could be given of such a transference of impulse, but now that modern microscopy has revealed the presence of protoplasmic threads passing through the cellulose walls of sensitive tissue, making the living matter continuous, the phenomenon in question may be understood as a manifestation of that fundamental property of protoplasm, irritability, to which we also refer the sensitiveness of animals, even though it be exhibited in a highly differentiated nervous system.

Since the irritability of the stamens is found so commonly

throughout the genus, we may assume the ancestral herbaceous barberry to have had the same peculiarity, but how this remarkable degree of sensitiveness could have arisen is not so clear. It would seem as if insect agency in some way or other must have brought about a movement having such an obviously purposeful relation to insect visits; but when we reflect upon the almost universal absence of a similar movement in flowers similarly visited, and the very questionable usefulness of the pronounced irritability of "sensitive" leaves, it is apparent that such a simple general explanation really explains very little. The few conjectures that the writer has to offer on the subject will be best understood after we have considered what may probably have been the evolution of certain structural peculiarities of the flower.

The anthers (Fig. 3, A), opening as they do by little valves hinged at the top, present a form of dehiscence confined entirely to the *Berberidaceæ*, the *Lauraceæ*, and a few other nearly related families not represented in our native flora. Within the *Berberidaceæ* all the genera except *Podophyllum* (the May apples) and *Nandina* have the anthers thus characterized; hence, it is clear that the stamens of the ancestral berberis were already of this peculiar type, and so the antecedent stages should be thought of as occurring in that line of berberidaceous herbs which were the forerunners of the barberries. The herbaceous genus *Podophyllum* contains species exhibiting a difference in the stamens which affords us an important clew for the understanding of what these antecedent stages may have been like. In *P. Emodi* (Fig. 13, A) the dehiscence of the anthers is by a longitudinal slit down the middle of each lobe. In *P. peltatum* (B), our common species, there is likewise a vertical slit, but it is so near the inner side of the connective that there appears to be but one valve to each lobe, the other inner valve having been reduced to a mere vestige. To connect this condition with that common elsewhere in the family, we need only suppose the attachment of the enlarged valve to become gradually narrowed by a continuation of the slit from below (C) until there remains only the small hinge we find in the barberry stamens of to-day (D). It deserves notice that the hinge, instead of being quite at the top, is nearer the back of the anther, which is what might be expected according to the hypothesis.

In the other families we have mentioned as exhibiting a valvular dehiscence of the anthers there is found almost invariably a pair of nectar glands on each filament (see Fig. 15). Now, it is a curious fact that in certain of the less highly developed mahonias the filaments are each provided with a pair of appendages (Fig. 14, A) similarly placed but being, so far as we know,

quite as functionless as are the cilia on the leaf margin of our common barberry. These cilia we saw good reason for believing to be rudimentary spines. The supposition that the stamen appendages are degenerate nectar glands would seem to be scarcely less probable, in spite of our inability to find as full a series of intermediate stages. For it should be remembered that the time

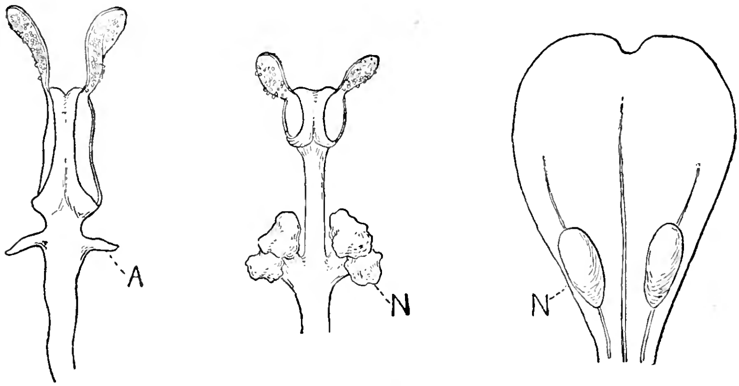

FIG. 14.—BERBERIS AQUIFOLIUM. Stamen showing appendages (A).
FIG. 15.—LINDERA BENZOIN. Stamen showing nectar glands (N).
FIG. 16.—BERBERIS VULGARIS. Petal showing nectar glands (N).

which has elapsed since the development of the floral peculiarities here considered is surely much greater than in the case of the foliar modifications, and consequently it would be strange indeed if the intermediate stages had not disappeared.

Although, in regard to the evolution of the floral organs, there is so much less opportunity than with the vegetative system to test the validity of our conjectures, yet it may not be entirely profitless to follow such clews as are available, and endeavor to reconstruct hypothetically the main features of those more primitive flowers from which the present barberry type was derived.

A multitude of stamens and pistils is generally recognized as characteristic of primitive flowers;* hence, we shall probably be not far wrong in considering the remote ancestor of the barberries and their kin to be in this regard very like a marsh marigold (*Caltha*), although doubtless less conspicuous, and with the parts more definitely arranged. As it is a very general characteristic of berberidaceous flowers that the parts are in whorls of three, we should expect this to be the case with the common ancestor. Accordingly, we arrive at a generalized type of flower, the structure of which may be expressed diagrammatically as in

* In the *Lardizabalaceæ*, an exotic group which some botanists consider to be a subfamily of *Berberidaceæ*, the pistils are from three to nine in number.

Fig. 17. At this stage we should also expect the flowers to be solitary, arising each from the axil of a leaf very similar to the rest of the plant's foliage.

Competition in securing the benefits of insect visits, together with the possibilities of a more economical as well as more effective disposition of tissue-building material, would conspire to bring about through natural selection the following changes:

1. Those branches of the herb on which flowers appeared would be given up more and more fully to their function of flower production; their subtending leaves would be reduced in size, and through a shortening of the axis the flowers would be brought closer together, and thus their conspicuousness enhanced. At the same time, part of the material saved might go to form additional flowers in the cluster. With the assumption of the shrubby habit the floral branches (peduncle, rhachis, and pedicels) retaining their herbaceous nature, in consequence of their short-lived usefulness, would appear still less like the others. The formation of flower buds to last over the winter would favor the blossoming of the flowers more nearly together in the follow-

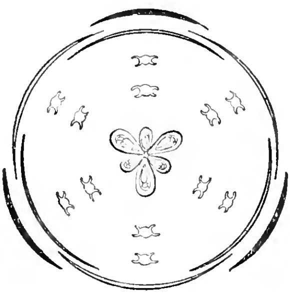

Fig. 17.

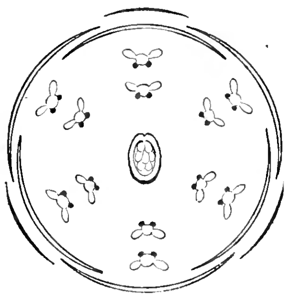

Fig. 18.

Fig. 17.—Diagram showing number and arrangement of parts in the primitive berberidaceous flower. Bracts, three (heavy black); sepals, six (outlined); stamens, twelve, dehiscence longitudinal; carpels, six, many-ovuled.

Fig. 18.—Diagram of flower (hypothetical) in a stage of evolution intermediate between the primitive form and the highest barberry type. Bracts and sepals as before; stamens, twelve, with valvular dehiscence and bearing nectar glands (heavy black); carpel, one, many-ovuled.

ing year. As the subtending leaves would now have lost almost the last vestige of their usefulness, we should expect their reduction to mere scales. The result of all this would be such a raceme as we find the barberry to possess (Fig. 2).

2. With the increase in the number of flowers in a cluster there would be less need for so many pistils in each flower. It might often happen that only a few of those in one flower would be fertilized, and in that case the store of food could be increased in the favored seeds, much to the advantage of the offspring produced. Pistils which ceased to have a use would gradually dis-

appear, until finally there would remain a single one of much increased serviceableness (Figs. 18 and 19).

3. For the reasons already given we may suppose the stamens to have their anthers so modified as to open by hinged valves,* while at the same time there was developed upon each filament a pair of nectar glands (Fig. 18). Insect visitors, finding an abundance of nectar in a flower, would be less likely to feed upon the pollen, which is so precious to the plant. As the position of the nectar is nearer the center of the flower, the visitor comes to occupy a more definite place relative to the pistil and stamens. The six stamens of the inner row are for the most part the only ones which can have their anthers touched, for, as will be seen from the diagram, the remainder are so placed as to be directly behind the others. Being thus superfluous as pollen-producers, the anthers of the other stamens would naturally degenerate, and if they follow the general rule of stamens in flowers which are provided with an abundance of building material (as, for example, the "double" flowers of the florists), they would change into something very like petals. If these petaloid organs became slightly arched over the inner stamens, they might still be of use in the floral household by giving better protection to the pollen than it had previously had, and at the same time increase somewhat the conspicuousness of the blossom. While it is by no means clear that any advantage is gained by having such an organ bilobed at the upper end, it might be a not unnatural result of that special part's having been derived from a bilobed anther. A glance at Figs. 3 and 16 will show that just such a petaloid organ is situated behind each of the stamens in a barberry flower.†

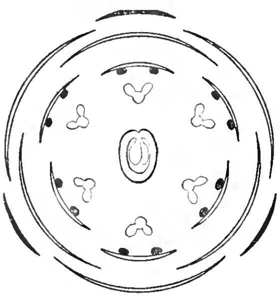

Fig. 19.—Diagram of euberberis flower. Bracts and sepals as before; petals, six, with nectar glands; stamens, six, with valves but no glands; carpel, one; ovules, few.

* If it be supposed that the flowers were originally erect, it is possible that this peculiar modification of the dehiscence may have arisen as a protection against rain, which would thus be hindered from washing away the pollen, or indeed quite prevented from so doing if the valve could have had that power of closing in wet weather and opening in dry which Kerner ascribes (Pflanzenleben, p. 123) to the anther valves of certain *Lauraceæ*. At the present day, as we have seen, the barberry stamens are so well shielded from the rain by the pendent attitude of the flowers that any such peculiarities of the anthers can hardly be of much service in this particular. Still, the assumption that this was equally true in the ancestral forms is of course unwarranted.

† In *B. vulgaris* it is the rule for these petals to be entire, its near relative, *B. canadensis*, having them bilobed. Fig. 3 and also Fig. 16 were, however, drawn directly from undoubted specimens of *B. vulgaris*.

The nectar glands of these hypothetical outer stamens, although situated behind the others, would not be disqualified in the least by such a position from continuing to perform their function. On the contrary, it might well happen that, as they no longer produced pollen, they would secrete all the more nectar in consequence, and thus relieve the inner stamens of so much of their work. No longer required, the glandular appendages of the latter would be reduced to rudiments (as in mahonias), or entirely disappear, as we have seen in the case of the true barberries.

Do the above considerations help us to any better understanding of how the irritability of the stamens came to be developed? In our previous consideration of this remarkable property, we saw reason to believe that such a peculiar manifestation of protoplasmic activity could only be satisfactorily explained as having resulted from a rare combination of favoring circumstances. Although, in the discussion of such a matter, we are confessedly treading upon uncertain ground, still, it may be worth while to inquire whether, supposing the barberry flower to have been evolved essentially after the manner indicated, there have not been thus happily combined the very factors we should deem necessary and adequate to produce this result. It should be remembered that we are not endeavoring to account for that fundamental property of protoplasm known as contractility, but only for its being in the stamens of the barberry so much more strikingly exhibited than in other organs of the plant, and in the great majority of other plants.

In the first place, in order that this or any other property of protoplasm should be especially well shown in any organ, it would seem to be a prerequisite that the organ should be unusually rich in protoplasm—a supposition which is confirmed by the comparative study of motile organs. Such a very considerable reduction of parts as we believe to have taken place in the barberry flower might well be connected with the enrichment of the remaining tissues.

Secondly, a mechanical stimulus applied repeatedly for innumerable generations, at a very definite part of the stamen, would seem to be also necessary in order to account for the fact that movement of the organ occurs in response to a touch only when applied to the front of the filament and near its base. From the position which the glands came to occupy in the flower, just such a stimulus was afforded by the proboscis of every insect that sipped the nectar.

Whether we are at liberty to suppose that the direct effects of such a repetition of stimuli may be accumulated through inheritance, or whether we must assume only the inheritance of fortuitous variations, is of comparatively small consequence in this

particular case, because the movement in question is undoubtedly useful, and as such, variations in this direction, be they fortuitous or mechanically induced, would be preserved by natural selection. In other words, an ever-recurring mechanical stimulus is presupposed even on the theory which works entirely with accidental variations, responding more or less fortunately thereto, while, if the stimulus be a direct cause of the favorable variations, its importance as a factor becomes still greater.*

Our theory of the origin of the peculiar movement in barberry stamens amounts, then, to this: Stimulation by contact at a definite part of the filament for innumerable generations, increase of the protoplasmic contents by the reduction of adjacent parts, and the usefulness of such a movement at every stage of its development—these three factors, although separately incompetent, have yet in combination been the ones chiefly concerned in bringing about through the agency of natural selection such changes in the protoplasm of the sensitive cells as make its fundamental property of contractility prominent to an extraordinary degree.

Fertilization being accomplished, the single pistil ripens into a berry. In *Berberis vulgaris* each of the two ovules ordinarily becomes a hard-coated seed flattened on its inner face by pressure (Fig. 20) in much the same way as happens with the two "beans" in a coffee berry. Sometimes (as in the so-called "male berry" coffee) one of the ovules aborts, thus leaving the other to form a seed proportionally richer in reserve food and correspondingly round in form. Occasionally there may be found barberry bushes producing fruit in which both ovules have aborted.† But according to Buckhout ‡ such individuals "do not constitute a permanent variety, for stoneless barberries are only found on old plants, and it has been proved that young suckers taken from them and planted in fresh soil fruit with perfect seeds." Seed production in this case would thus seem to be a question of the plant's vigor at a given period, and so to be comparable with the case of ordi-

* The belief that stimuli of the sort described directly induce modifications which are inherited has of late years been advocated by Rev. George Henslow (The Origin of Floral Structures). But before this supposition can be accepted in the present case, we surely require an explanation of how it might be possible for changes induced in the protoplasm of the mature stamens of a given flower to exert a modifying effect on the pollen grains, or the female germ cells, for inheritance must, of course, proceed from them. The pollen grains being separate and distinct, and the female germ cells fully formed and presumably isolated from surrounding protoplasm at the time of the insect's visit, the difficulty suggested would seem to be a very serious one, and, so far as the writer is aware, not even a plausible explanation on this point has been offered.

† Sturtevant (On Seedless Fruits, Mem. Torr. Bot. Club, vol. ii, p. 3) cites a number of authors who have noticed this phenomenon in barberries.

‡ Treasury of Botany, vol. i, p. 136.

nary seedless varieties (such as bananas, navel oranges, and the tiny seedless grapes sold as dried "currants") only on the supposition that in the latter also there had been a loss of vigor through long-continued non-sexual propagation.

The agreeable tartness of the barberry fruit, which makes it so generally and so highly esteemed, is due to the presence of malic acid, a substance found also in the foliage. Besides being made into preserves and jellies, the ripe fruit is candied or may be dried like raisins. While yet green the berries are sometimes pickled as a substitute for capers. Barberry preserve is, moreover, often used as the basis of a refreshing summer drink —a sort of "barberryade." Finally, it is reported that in our Western States the fruit of *Berberis aquifolium* and certain other native species is made to yield upon fermentation an agreeable wine.

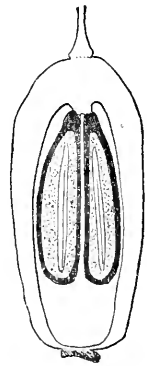

Fig. 20.—Berberis vulgaris. Vertical section of berry, showing two seeds, each containing copious reserve food and a long, well-developed embryo.

But, for all their attractiveness to us, the berries seem to be less in favor with birds than are many fruits which we care nothing for. So long as the more succulent or less acid fruits are to be obtained, birds visit the barberry but little. When winter comes, however, they are glad enough to profit by the barberry's offer of something to eat, and the bright scarlet clusters do not dangle in vain.

Kerner fed certain thrushes with barberries, and found that the resistant seeds not only passed unharmed through the digestive tract, but their power of germination was improved, as shown by comparing them with seeds which had not been eaten. Add to this advantage the long distances which birds are likely to carry the seeds they eat, and the likelihood of their depositing them in most favorable situations, and it will at once be apparent how much superior to other methods is this mode of dissemination.

There can be little doubt that in the primitive ancestors of the barberry family the fruits were dry capsules which depended upon the wind to distribute their numerous seeds, as is the case to-day in the majority of herbaceous *Berberidaceæ*. That is to say, if we suppose the six pistils of the primitive berberidaceous flower (see Fig. 17) to have ripened into as many capsules, we shall have a form of fruit from which not improbably may have been derived all the different forms of fruit exhibited in modern representatives of the family. Confining our attention to the line which culminates in the barberry, it will be seen that the supposition of such a fruit's having descended from the primitive form above men-

tioned involves the assumption of the following changes: (1) The disappearance of all but one of the pistils; (2) reduction of the number of seeds; (3) the abandonment of dehiscence; (4) increased hardness of seed coat; (5) the acquirement of succulence; (6) the development of an attractive color.

The first-named alteration we have already considered in connection with the evolution of the flower. As with this, so with the other changes, the best we can do is to imagine how they might have come about. Now, it is true of all capsular fruits that until fully ripe they are neither dry nor dehiscent. We know that variations in the time of ripening do occur, and experiments have shown* that even unripe seeds will germinate and produce strong, healthy plants. In view of these facts it seems reasonable to suppose that not only might there arise varieties in which the capsule would retain something of its succulence until the seeds were nearly ripe, but if the fruit in this condition were eaten by birds or other animals the seeds might be disseminated by them, much to the benefit of the favored variety. There were doubtless seasons of scarcity in prehistoric times as well as now, when animals would be glad of even such comparatively unattractive fruits as we have described. Among the descendants of those plants whose fruits had become somewhat berrylike, those having the more succulent pericarp would, other things being equal, have most descendants, and thus in the course of many generations the present condition be reached.

The conspicuousness, depending as it does upon the same changes in the original pigment as occur in the transformations of chlorophyll in autumn leaves, may be looked upon as a result incidentally connected with the retention of succulence in the pericarp after growth had ceased, and as this tendency for the fruit to assume a color contrasting with the foliage would be beneficial as an advertisement to birds, natural selection would favor rather than hinder it.

The fact that in mahonias the berries are commonly of a dark purplish blue suggests that possibly this was the color first assumed by the fruit of the genus, the more conspicuous scarlet of the common barberry and its near relatives being acquired later, along with the higher differentiation of structure which it accompanies. Although this view gains some support from the occasional appearance of a blue-fruited variety of *Berberis vulgaris* (which might be thought of as a reversion to the ancestral type), still it should be remembered that our knowledge of the chemistry of plant pigments is at best too meager to justify much confidence in any theory of color change.

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* Goodale, Physiol. Bot., p. 460.

When once the good services of birds had been secured, there would be no need of having so many seeds in each fruit as must have been formerly necessary to compensate for the extreme wastefulness of wind as a distributing agent. At the same time a reduction in the number would permit, as we have already had occasion to notice, a higher development of each remaining seed—that is to say, an increase of reserve food and a thickening of the outer coat, features that we find to vary directly as the number of seeds, there being all the way from eight (in many mahonias) to two or even one in the true barberries.

However the characteristics of the barberry fruit may have arisen, the fact that they came to depend upon birds for their dissemination must have exerted an important influence upon all the subsequent differentiation of the group, for barberries were thus brought into widely separated regions which they might not otherwise have reached and so came to grow up in widely different surroundings.

We have already considered the extent of the migrations which are believed to have taken place in preglacial times. Among the forms which became adapted to the refrigerated climate that heralded the Glacial epoch, one of the most successful was probably a form almost if not quite identical with the modern *Berberis canadensis,* which despite its name does not grow in Canada, but is found only in the Alleghanies of Virginia and southward. Before the glacier came, however, the ancestral form we are speaking of probably did occur even to the north of Canada, and through the agency of birds was carried into Asia and distributed widely on that continent. Under the influence of their new environment it would not be strange if in the Asiatic descendants of the *canadensis* stock there appeared, even during the (geologically) short time since the beginning of the Glacial period, those slight differences which now distinguish *Berberis vulgaris* from the American descendants—differences which in the minds of some botanists entitle the two forms to rank only as varieties of the same species. After the retreat of the glacier, *Berberis vulgaris* extends into Europe to take the place of the mahonias previously exterminated. It now flourishes from England to Persia and from Persia to Japan. Our forefathers bring the plant to this country (largely for the sake of its fruit), and thus it finally returns to the ancestral acres. It would surely seem to be not a little invigorated by its journey around the world, since in the acquisition of American territory it appears to be in a fair way to outdo its stay-at-home relative, and has already fully justified with us its Old World name of " common barberry."

[*Concluded.*]

THE PROFESSIONAL TRAINING OF TEACHERS.

By M. V. O'SHEA.

ONE whose attention has been directed to the great activity which has taken hold of the modern educational world can not but have concluded that teaching has come to be regarded as a more or less difficult art, for which considerable preparation must be made in order that one shall be fitted to do it at all well. The present age has not been heir to such a view as this, however; for it has been comparatively recent that men have grown to consider the imparting of instruction successfully as an art to be acquired; they have looked upon it rather as an instinct that is born with its possessor, and that shows itself in some such spontaneous manner as do other characteristics and habits that lie outside of personal thought or control. The maxim that poets are "born, not made," has been applied with much vigor also to the great majority of teachers, who have themselves oftentimes not thought it necessary or expedient to make any definite preparation for their calling, other than to acquire a certain familiarity with the arithmetic or grammar or geography, knowledge of which they innocently hope to pour into their pupils' minds out of their own store of facts in these subjects. Educational practice of to-day, however, is not wholly in sympathy with the declaration that a teacher's art is born with him and can not be acquired; for it has provided elaborate means for the making of teachers, or at least for affording them opportunities to greatly improve upon what Nature has done for them. This has grown out of the belief that teaching is founded upon a science, and its successful practice must be acquired by special study and apprenticeship, just as with any other art, like civil engineering or architecture or medicine. Confidence in this opinion has spread widely throughout our own and other countries, and has resulted in the vast increase of means whereby every teacher may now have opportunity to become possessed in some measure of those special acquirements which, it is believed, are essential in order that he shall deal wisely with childhood in the schoolroom.

Previous to the eighteenth century there seems to have been no adequate conception of the training of mind as being amenable to the rules and methods of science. It was probably not thought that the mental life was subject to laws the nature of which could be ascertained, and which would have to be followed if there would be any success in leading the mind to attain those ends which should be kept constantly in view in all educational work. The teacher, then, would be successful according to the measure of his instinctive apprehension of the peculiar nature of each pu-

pil's mind; and there would not be much opportunity to increase his success by careful observation and study of a large number of children. The first recognition of teaching as an art, founded upon a rather indefinite science of the mind, seems to have been shown by the Jesuits in the seventeenth century, when they required every individual who should teach in their schools to spend two or three years as an apprentice, observing the ways of a master, who was supposed to have become familiar with the best art of teaching through his own experience in observation and experimentation. Later, Ratich urged that teaching was an art, and that those who were to practice it must become familiar with its rules and devices before trying it, lest those whom they should attempt to instruct should suffer by their ignorance and unskillfulness until experience should have taught them wisdom. In the eighteenth century Francke embodied this idea in his schools at Halle, requiring that all his teachers should, before being fully admitted to the profession, spend two or three years in observing others teach, and in reflecting upon the difficulties to be met with and devising means to overcome them. This was the forerunner of the "teacher's seminary," which has latterly spread throughout Germany and all the progressive countries of Europe; and which has crossed over the waters to our own land, where a different name has been taken, but where the same ends are aimed at. Previous to 1833 there were in France, according to Guizot, forty-seven primary normal schools, while at present there are one hundred and seventy-one well-equipped institutions, all of which have become governmental institutions. In 1827 David Stowe established the first normal seminary in Great Britain, at Glasgow; and such great popularity did this attain that other institutions of the same kind sprang up rapidly throughout Scotland and England, while training colleges and professorships of pedagogy in the universities have also been established. The first normal school in our own country began operations at Lexington, Mass., in 1829, and now there is not a State in the Union that has not several of these schools, supported at public expense; while normal colleges and professorships of pedagogy are meeting with favor and multiplying in all parts of the country.

In America there is a problem to be met in the training of teachers that gives very little trouble to many of the countries of the Old World. In Germany, Austria, France, and the other important nations of Europe, teaching has come to be regarded as a profession which, when an individual once enters, he rarely deserts, holding to it for life the same as if he had engaged in the practice of medicine or law. The population of these countries is practically constant, making it possible to determine pretty definitely about how many teachers will be required each year to

meet the demands of the public schools. On this account the teacher is reasonably certain of finding and holding a place in his profession if he enters it properly prepared; and the governments of these countries can say that no teacher shall engage in the practice of his profession until he shall have had the normal school or training-seminary preparation, which is provided free, under the provision that the beneficiary shall devote himself during his life, or a certain portion of it, to the work of teaching in the public institutions of the country. In our own country teaching is not yet regarded as a profession to any great extent; and a majority of those engaged in it do not continue in it for a long time, perhaps not more than two or three years. The greater number of teachers are women whose tenure of office in the schools is tentative, depending upon the time when they shall find more attractive life work; while most of the men who enlist under the banner of the schoolmaster do so only as preliminary to engaging in other and more remunerative professions when fortune favors. This uncertainty in things makes a thorough and systematic training of teachers in anything like completeness impossible in our own country at the present time. However, so thoroughly is it recognized by those familiar with the question that teaching is an art to be improved upon by special study, even by those possessing the most favorable endowments, that provisions are made for *some* professional training of every candidate for a place as master in the schools. This is done through teachers' institutes in all the States, summer schools, teachers' training classes in the high schools, normal schools, and departments and chairs of pedagogy in the universities; and by means of these agencies almost every teacher receives more or less professional instruction which enables her to grasp the problem she is to undertake in the management of a school in a more skilled and scientific manner. But, while not disparaging the work done by any and all of these agencies, it must still be said that it is to our normal schools that we must look for anything like that preparation and training which must be demanded of our teachers before our schools shall be able to realize adequately those ends for which they are established and maintained.

Something has been written against the normal-school idea by those who feel that the art of teaching successfully must spring up spontaneously out of the teacher's nature, since if it comes in any other way, through study and apprenticeship, it will be stilted, forced, and unnatural; and it is further urged that teachers who are thus made are more harmful than none at all. It has been held in some quarters that the normal school puts into the hands of its students a system of artificial makeshifts that prevent the outworking of individuality, and reduce all teach-

ing to mere mechanism and parrotlike imitation. "They make fine-working machines of our teachers," some still say, "but we would rather have spontaneous activity, even though ignorant and crude, than the finest action on the part of a machine." This criticism of the normal school has served a wholesome purpose in breaking up any tendency toward mechanism and spiritless, formal methods of teaching which might have been displayed in its earlier inception. It seems to be always true that in the beginning of any great institution like the normal school the letter and not the spirit will be at first emphasized; but in the process of healthy evolution the mechanical part becomes simply the means of expression of the principles and truths underlying. This has, no doubt, been true of the normal school; and, in its steady growth toward a more scientific basis for all it does, it has come to pass that at the present time its work in the training of teachers is made to cover the broadest and fullest possible view of the human being and the purpose of his education. It is recognized that the process of education from first to last is dependent upon laws of the human mind, and it is partly the province of the normal school to determine what those laws are. And further, when the aims and ends of education have been decided upon, the normal school must show what are the simplest, most speedy, and most certain ways of attaining those ends. If we look briefly at the work of the normal school as we have it now, we shall see that the charge of its being unduly mechanical and too feebly scientific can not be applied to it in its present stage of evolution.

The one ruling aim which gives character to the professional work in the normal school is the purpose to awaken in the teacher a consciousness that there is a science of education, and an art of teaching founded upon that science; to arouse in her an earnest, indefatigable ambition to become acquainted with the best in both, and, most important of all, to lead her to realize this in her own work. The distinguishing characteristic of professional instruction, which marks it off from purely academic study, is the attempt to acquaint students with the *teaching* aspect of subjects of instruction, and to lead them to become students of all the conditions in their schoolrooms that affect the action of the minds of pupils in responding to all the means of stimulation which the teacher consciously makes use of to attain the ends of development. In other words, it is aimed to make the teacher conscious of her art—conscious in the sense that she will intelligently consider the growing, developing mind, acting according to definite, exact laws; and that she will attempt to wisely use the agencies at her disposal in harmony with these laws to accomplish in the most ready manner the highest possible ends of school train-

ing. It appears, then, that the entire work in the professional training of teachers consists of an investigation into the laws and principles of mind activity, always followed by the effort to rightly adapt the means of stimulation in the schoolroom (the various subjects of instruction) to attain the full, harmonious, capable development of child-nature. In the normal school this work is usually divided into several branches, which, however, are very vitally related, and which are always arranged in the natural order of sequence. The following is, in general, a very brief outline of the work which is usually attempted in each branch:

I. Psychology.—The professional work is most naturally begun by reflection upon the nature of the mind to be educated, endeavoring to find those laws and principles according to which its normal activity is regulated in order that we may intelligently wield the means of stimulation to secure its most natural and speedy development. There are two methods which may be followed in this study: The first assumes that the mind is an inert object which can be abstracted from all concrete cases, and by an analytic process separated into its logical parts. As a result of this treatment we have a formal science of psychology, dealing with the powers and attributes of the so-called faculties of the mind, in the same way that we have a formal science of mathematics, physics, and so on, that treat of characteristic subject-matter in a logical way. The second method, which has come to be followed most largely now in our training schools, regards the mind as a growing, developing, assimilating power, and it is sought to become acquainted with it while under these natural conditions of activity. A knowledge of the mental life gained in this latter way will be very different from that acquired by purely formal study where the mind is considered apart from all concrete instances, and laws and principles are deduced which may be applicable to it in general, but which have no reference to the peculiar and distinguishing characteristics of specific instances, nor of the manifold modifying conditions under which all activity, as induced by educational agencies, occurs. It should be, and usually is, the aim to lead the prospective teacher to become somewhat familiar with the concrete and developing mind under those conditions which necessarily exist in all school work. It is generally true that those who seek the normal school have not the time nor the breadth of philosophical training and culture to enable them to make the study of formal psychology profitable, although it would be most valuable for one who could spend years in thought and reflection upon the matter, and who would not need to make practical application at once of the principles which he had considered. It is coming to be appreciated that while a teacher need not, in order to do most intelligent

work, be learned in the logical principles and divisions of mind activity, yet he does need to become acquainted with the action of the mind as it is manifested in the many concrete cases which are constantly before him in his daily work. He must come to feel that the mind acts according to law, definite, exact, and unerring, as well with reference to the subject-matter by which it is disciplined in the schools as to its reaction upon sense stimulus. He must be trained to observe the effect of all external conditions, bodily and otherwise, which do in any way modify or affect the mental and moral condition of the child; and it certainly can not be maintained that this study leads the teacher to become imitative and formal in his own class room.

Throughout all this work an effort is usually made to have the prospective teacher discover for himself the more obvious principles of mental activity, both by reflection upon the activities of his own mental life and by the observation of mind phenomena in the world about him. He is led to discern the intimate relation between body and mind, to discover for himself the law of mutual affection, and to trace the application of this fact in educational procedure. So it will be seen that the purpose is to initiate him into the habits of careful, intelligent observation of the facts of mental activity as displayed under the ordinary conditions of the class room, and to lead him to make correct, serviceable interpretations of what he observes. As an aid toward this, many normal schools include in their curricula special studies of child-nature in the concrete, in order to train teachers to habits of exact, scientific study of individual pupils under their charge, and also these individuals when they are combined into classes. The value of this work, when it is carried on intelligently, can not be overestimated; for it leads the teacher into those habits of trying to find some remediable cause for every undesirable manifestation of child-nature in the class room which constitute the most praiseworthy and serviceable attainments that those who deal with children can become possessed of. Such study is usually of great benefit to teachers by pointing out to them defects in vision and other physical imperfections in pupils, which render them incapable of the highest and best work which they could otherwise successfully undertake. The pupil teacher is made to realize that the environment of his own pupils will be a potent factor in determining the mental and moral effect which the means of stimulation in the school will have upon them; and he is further led to appreciate the maxim that in a great measure a teacher's success will depend upon his ability to perceive clearly the effect of external conditions, and to be able to arrange and modify them so that they will all operate toward the accomplishment of those ends which he is consciously seeking. It seems that such study as this

will bring the teacher into broadest sympathy with child-nature, and will enable him to affect peculiar natures and dispositions in such manner as to establish wholesome and desirable ways of action. It certainly is not true that the teacher is made a machine by work of this character; on the contrary, he is brought into the highest possible freedom by finding the truth in the objects with which he is to deal. How infinitely more free he becomes than when he remains the creature of his own ignorance and preconceived notions of the one formal way to deal with child-nature!

II. THE SCIENCE OF EDUCATION.—It has already been said that the study of psychology, for the teacher, must be of such character that he will be enabled to apply it practically in the daily work of instruction in the schoolroom; for so long as it remains merely theoretical he has received no benefit from it whatever, at least so far as he is professionally concerned. It follows readily, then, that the principles of the science of education must be gained simply as generalizations from the facts of psychology, viewed with reference to the conscious and scientific stimulation of the mind by educational agencies; and this is all that is attempted in this subject as the normal school has to deal with it. This study is but a continuation of the study of psychology from a special point of view—that of finding an order or method in education as determined by the facts which have been found in our observation of mind phenomena. It is continually emphasized in the normal school that all method in education is naturally and entirely dependent upon laws of mental growth and development. It is the purpose in this place to investigate the general principles which underlie all right educational procedure, with the end in view to lead the teacher to become conscious of the laws regulating the order both of the parts of the branches of instruction and of the branches themselves when they are considered with reference to training the mind; and it is believed that in this way he gains a knowledge of educational method and practice so wide and broad that there will be little danger of his mistaking the mechanism of school teaching, as exemplified by some individual who happens to be his instructor, for the true spirit as the body of it all. The ordinary student will not readily apply principles in which the concrete cases from which they are drawn are not clearly apparent; but in the consideration of such processes as induction, deduction, apperception, concentration, interest, attention, and so on, he will have no difficulty in seeing their universal application in all the work of instruction, especially if he is led to discover their importance by his own investigation.

There has been some objection on the part of certain philosophers to the proposition that there is or can be a science of edu-

cation. It is maintained that, on account of the changeableness of human life, the diversity of human nature, the varying ideals of educational practice, and so on, educational method must consequently be in a continual flux, with no certainty or definiteness about it. Perhaps all persons looking at a science of education from this point of view would agree that there must be a change of procedure to accommodate changing interests and ideals; but there is unanimity of opinion between educators and psychologists that the natural processes of the mind under stimulation by educational agencies do not vary for individuals or periods of time, or for theories as to the aims and ends of education. There is common agreement that the inductive process is the only one that the child mind can follow in getting its first knowledge of any branch of instruction, and this law must be universal. So, too, it is agreed that in every instance it is impossible to appropriate information of any character unless there is a swinging of the mind toward the object of which knowledge is to be gained, that is, unless there is an act of attention. And, again, it is coming to be realized more and more that there is a vital relation between the now many and varied branches of instruction—a relation which unites them so closely that the human mind grasps and appreciates them when presented together more naturally than when it tries to get them separately and disjointedly; and this also must be true for all time and all individuals. It is upon these and other uniform certainties that a science of education may be built, and there is no necessity to attempt to include within it all the uncertainties over which there seems to have been some worriment.

III. The Art of Teaching.—When the teacher has become familiar with those general principles which must be observed in all the work of education, he is led to investigate the order and method in each of the various branches of instruction found in the schoolroom, to the end that he may present each one to the child-mind in a manner befitting its peculiar nature. From this study it will be found that the child acquires a knowledge of language and the use of it in a somewhat different way from that in which he masters the subject-matter of arithmetic and is able to use it as required. The apprentice teacher must come to understand and appreciate that the operation of the mind is not the same in gaining each and every subject which she uses in the schoolroom for its development; and this is often a great revelation to the novice, who little suspects that there is such diversity in things pedagogical. In this connection the student is made acquainted with those forms and devices for teaching each subject which best illustrate the psychological principles that have already been agreed upon. This work has been given the name of

"special methods," because it deals minutely with the principles of teaching each particular subject, and suggests also in some measure the mechanics that has been found adapted to each subject; and it is this latter kind of work that has brought more or less disrepute upon the normal school. But when a teacher is required to continue with this phase of his work until he is thoroughly able to comprehend that all devices and forms of teaching are but efforts of individuals to best illustrate the underlying principles, and when he is expected to work out a system of devices for himself before he leaves the school, then there is little danger of his falling into mechanical habits that will interfere with that spontaneity which is all-essential in spirited teaching. The normal school does not now emphasize the mechanical side of teaching as much as it did when the knowledge of psychology was so meager that pupil teachers could not hope to be investigators of the principles which underlie educational method, but must be content to be imitators of those who had made researches, and embodied these in an art which necessarily exhibited much of their own individuality. Every trained teacher is required in these times to study the mind of the child; and he is led to see that the whole realm of methods and devices must be built upon the laws of mental growth, and everything that has not this scientific basis is worthless and even injurious.

As a necessary part of this work in the art of teaching there is provision made in the normal school whereby theory may be illustrated in actual practice in the model, or practice, school. It is the aim in this school to show the application of principles and the proper use of devices by an abundance of illustrative teaching of such character that the apprentice may well emulate it in all respects. It has become a familiar truth that it is with teaching as with other callings in life—that in order to become able most speedily to do creditable work the candidate should have his attention specially directed to those qualities and accomplishments which mark successful teaching, because he will not, in all probability, appreciate them unless they are thus pointed out to him. It can not be too strongly emphasized that object lessons in successful teaching are as important and exemplify the same pedagogical doctrine as is the case in other departments of educational work. In this illustrative teaching the apprentice is required to analyze carefully and fully all the lessons which he observes, not only from the point of view of the essential principles underlying them, but he must take into account also the surrounding and accompanying conditions which materially affect the lesson favorably or unfavorably. Every student is trained to see and appreciate pedagogical problems, and he is expected to become able to point out an intelligent and practical way for their solution.

The practice department of the normal school usually illustrates a thoroughly graded and classified school from the kindergarten to the high school, and is designed to embody three phases of actual teaching: In the first place, as has been said, pupil teachers are expected to witness model teaching that exemplifies the very best psychological principles in order that they may have the very best ideals set before them. Second, every pupil teacher is required to teach for a certain length of time in this practice department under skilled criticism. The critic teacher, who is usually an experienced and competent person, is careful to point out the defects which the student displays in his practice work, and to give him explicit directions how to overcome them, always aiding him in every way possible to apply readily and efficiently the principles he has gained in his theoretical work. In the third place, there is usually a spirit of investigation found in these practice schools, seeking constantly to improve upon the methods of teaching which may be in vogue at any time; and, as a general thing, freedom is permitted the apprentice to work out original methods, provided these seem to be in harmony with the fundamental principles of teaching. It is not too much to say that it is the aim always to inculcate among pupil teachers that broad, wholesome spirit that will look upon the teaching profession as a high and honorable one, where more worthy motives should prevail than those of mercenary gain or social preferment.

IV. The History of Education.—In order that a teacher shall thoroughly understand and appreciate what is being done pedagogically in these times it is necessary that he be led to see how the present state of things has been brought about, in order that he may put himself in line with the ascending tide in educational practice. The history of education, as a record of the development of educational ideas and practices, showing the transition from a period of unpedagogical and unpsychological procedure to one with more humane and intelligent methods, is as stimulative and beneficial a study as a teacher can undertake. The aim generally kept in mind is to trace the process of developing pedagogical ideas with the end in view to see that there is and has been a constant evolution along several distinct lines of educational practice, and that we are at present in a stage of that evolution process which seems in no wise to be near completion. The apprentice is led to appreciate that there has been in educational history much the same awakening to the consciousness that there is a teaching science, determined by invariable laws of mind growth and development, as is experienced by the ordinary teacher who has come to look at her work from a psychological rather than an academic standpoint. An effort is made to have

the student trace the growth of progressive ideas through the different ages and combine this knowledge into one organic whole; instead of becoming possessed of a chaos of unrelated facts which may give general information, but can not be organized to afford intelligent direction to the efforts of the student who tries to meet the problems which confront him continually in his work. Surely there can be no broader study for the prospective teacher than to examine critically the great systems of pedagogical doctrine out of which our own has grown; such, for example, as those elaborated by Comenius, Rousseau, Basedow, Pestalozzi, Froebel, Herbart, Spencer, Mann, and others, and to profit by the successes and failures of these systems so far as they have been tried, and also to gain inspiration and courage from their exponents.

This in brief is what the normal school attempts to do for the professional betterment of those who seek its privileges. That there is great opportunity yet for growth every one admits; but no one who is in touch with the normal school will doubt that it is moving forward as rapidly as the law of growth of such an institution, conditioned as it is by the development of the school system as a whole of which it is a part, will admit; and that it is now filling a great mission (even with all its imperfections on its head) in improving the present condition of our schools, and pointing to higher and better things in the future, is amply shown on every side by the results of its efforts.

FUNERAL CUSTOMS OF THE WORLD.

By J. H. LONG.

A WRITER on the subject of the disposal of the bodies of the dead has said, "As there is almost nothing else so deeply interesting to the living as the disposal of those whom they have loved and lost, so there is perhaps nothing else so distinctive of the condition and character of a people as the method in which they treat their dead." It may be premised, then, that no custom stamps the standing of a people more clearly in the scale of civilization than does the care of the bodies of the departed. "People of a low and barbarous type carelessly permit the remains of the dead to lie in the way of the living, and there are a few instances in which the object of artificial arrangements has been to preserve a decorated portion of the body—as, for example, a gilded skull—among the survivors." The general tendency of mankind, however, has been to bury the dead out of the sight of the living; and various as the methods of accomplishing this end have been, they have resolved themselves into three

great divisions: (1) The simple closing up of the body in earth or stone; (2) the burning of the body and the entombing of the cinders; (3) the embalming of the body.

The first of these, i. e., the simple inclosing of the body in earth or stone, is not only the most widely diffused of the three, but also the earliest of which we have any record. It is referred to again and again in Scripture, although the other methods also are mentioned. A beautiful description of one of the most ancient of Bible burials is found in the twenty-third chapter of Genesis. It was considered by the Hebrews one of the greatest calamities and deepest marks of dishonor to be deprived of burial. So we read in the prophecy of Jeremiah against Jehoiakim, "He shall be buried with the burial of an ass, drawn and cast forth beyond the gates of Jerusalem." Evidently, next to the simple exposure of the body, which savored too much of cruel neglect, burial was the first means that would suggest itself to the human race for the disposal of the remains of the dead. In the beginning the rite was no doubt simple and unostentatious; but, as civilization advanced, it became more and more ornate, reaching in some lands and ages a pitch of ceremonial magnificence which seems incredible to us now, but relics of which are still seen in our modern funeral displays. There can be nothing more magnificent than the obsequies of a high dignitary of the Greek or the Roman Church. But still, to those outside these churches all such ceremonies appear just a little tawdry and garish. It is doubtful whether there is, or can be, any funeral ceremony so truly solemn as that which is held in Westminster Abbey. In such a burial there is everything calculated to evoke the most reverential, the most solemn thoughts—the dim religious light stealing through the painted windows far up against the sky; the long vista of arch and pillar and tomb; the silence, broken only by the solemn service for the dead, the deep roll of the organ, and the voices of the singers like the singing of angels far away; more than all else, the thought that everywhere about us lies the dust of those who once filled the world with their fame, from the days of St. Edward the founder, yes, from the days of Sebert the Saxon king. A burial at Westminster marks the highest point ever reached by this form of sepulture. It stands at one end of the series. At the other end stand those hideous rites which have been practiced in many a heathen land: in Ashantee, in Dahomey, in ancient Mexico, in certain of the south sea islands, and (formerly) in India. Let me epitomize two or three extracts bearing on this: "Herodotus tells us that when a king died in ancient Scythia, those who attended him cut off one ear, shaved their heads, wounded themselves on the arm, forehead, and nose, and pierced the left

hand with an arrow. Furthermore, the undertakers or managers of the royal funeral had to furnish a woman, a cup-bearer, a cook, a waiter, a messenger, and a certain number of horses; all to be killed. In fact, in the particular king's funeral which the great Greek historian is describing they took the king's ministers, fifty in number, and strangled them. Then, having killed fifty of the chief horses of the king, they prepared them and set them in a circle, upon each one a strangled rider, that they might serve as a royal guard to the dead hero." "The chiefs of the Fiji Islands have from fifty to one hundred wives, according to their rank. At the interment of a principal chief the body is laid in state upon a spacious lawn in the presence of an immense concourse of spectators. The principal wife, after the utmost ingenuity of the natives has been exercised in adorning her person, then walks out and takes her seat near the body of her husband. A rope is passed round her neck, which eight or ten powerful men pull, until she is strangled and dies. Her body is then laid by that of the chief. In this manner four wives are sacrificed, and all of them are interred in a common grave, one above, one below, and one on either side of the husband. This is done that the spirit of the chief be not lonely in its passage to the invisible world, and that, by such an offering, its happiness may be at once secured." It may be added to this that, in certain lands, the custom is to inter *alive* the attendants of the dead chieftain; it being believed that this precaution adds to the solemnity of the occasion and to the future happiness of the departed. In ancient Mexico this practice of sacrificing upon the occasion of a funeral was carried on with great pomp and lavish effusion of blood, in some cases a hundred persons being slain to act as guides and servitors to the deceased chief in his journey to the other world. In India, owing to the kindly offices of the British Government, the terrible suttee has entirely disappeared. This, it is needless to say, was the custom of self-sacrifice by the wife of the dead husband. It is impossible not to admire the heroic spirit of those Hindoo widows who deemed it a high honor to cast themselves upon the funeral pyre of their spouse. "Indeed, when the female slaves find their mistress is greatly afflicted at the loss of her husband, they promise her, in case she is resolved not to survive him, to burn themselves along with her, and are always as good as their word. They dance near the funeral pyre, and throw themselves into it, one after another."

The two other modes of sepulture are, as has been said, embalming and cremation. Embalming was not unknown among the ancient Hebrews: there is frequent allusion in the later Scriptures, and especially in the New Testament, to the embalming of the body in antiseptics and fragrant substances. But the land

which was distinctively the land of embalming was Egypt. This subject is so vast that it is possible to refer to but two or three points. One is the peculiar custom of judging the dead, before a monument might be erected or other honor paid to their memory. A writer on this subject says: "The judges who were to examine into the merits of the deceased met on the opposite sides of a lake. . . . When the judges met, all those who had anything to object against the deceased person were heard; and, if it appeared that he had been a wicked person, then his name was condemned to perpetual infamy, nor could his dearest relatives erect any monument to perpetuate his memory. This made a lasting impression upon the minds of the people, for nothing operates more strongly than the fear of shame and the consideration of our deceased relatives being consigned to infamy hereafter. Kings themselves were not exempted from this inquiry; all their actions were canvassed at large by the judges, and the same impartial decision took place as if it had been upon the meanest of the subjects." This trial, which is described in the Book of the Dead, was a foreshadowing of the trial of the soul by Osiris and his brother judges, before it might be received into the Elysian Fields or the Pools of Perfect Peace. The requirements for passing this latter ordeal were very much the same as those set forth in the Sermon on the Mount: to care for the fatherless and the widow; to give food to the hungry, drink to the thirsty, clothes to the naked, oil to the wounded, and burial to the dead; to be faithful to the king, and loving to wife and child.

Another point deserving of notice was the strange custom of placing the mummy in the seat of honor in the banquet hall. This had a twofold office: (1) To warn the living of the fate in store for them, like the *memento mori* of the Romans; (2) to show honor to ancestors. So it came to pass that of all lands in the world, Egypt—so rich in obelisk and pyramid and needle; Egypt, whose air does not destroy, but preserves—is also the richest in these mute memorials of the once-living dead. What a marvelous thing it is that we may to-day gaze upon the very face and form of the Pharaoh who would not let Israel go, of him who built the treasure cities of the plain!

The third method of disposing of the dead is by burning—cremation, as it is now called. Many nations have practiced burning, the best instances being the Greeks and the Romans. Among the Greeks both methods were employed—burning and burying; but gradually burning came to be the popular mode, the reason being that fire was supposed to purify the celestial part of man by separating it from the defilements of the body, and thus enabling it to wing its flight to purer realms. More than the Greeks the Romans were devoted to the process of cremation, al-

though in early ages they buried their dead. Cremation became general at the end of the republic, i. e., shortly before the birth of Christ. Under the emperors it was almost universal, but it gradually disappeared as Christianity gained sway. The Roman burial rites were very rigorous and voluminous. The ceremonial of a modern funeral is as nothing compared with the Roman ceremonial. There were the musicians, the players, the imitator (who personated the dead), the images of the deceased, the train of slaves and freedmen, the relatives tearing their garments and covering themselves with dust, the funeral oration, and the final obsequies at the pyre. This pyre was built in the form of an altar of four sides. On it was placed the corpse upon a couch. The eyes of the deceased were opened, the near relatives kissed the body with tears; and then, turning away their faces, they applied the torch, while upon the burning mass were cast perfumes of myrrh and cassia, the clothes and ornaments of the dead, and offerings of various kinds. At an officer's funeral the soldiers made a circuit three times round the pyre, the ensigns reversed, the trumpets braying, and the weapons clashing. If he had been very popular, the soldiers cast their weapons upon the burning mass as loving offerings to their dead commander. The ashes were then gathered and put into an urn. Thus preserved, they were deposited in one of those tombs which still adorn the stately roads of Rome. Often lamps were kept perpetually burning in the tomb, while flowers and chaplets were brought thither, that the dead might be reminded of the loving memory of the living.

This mention of the burning of the body in ancient times leads naturally to the question of cremation, which is attracting attention to-day, not so much in lands of sparse population as in lands such as England, Belgium, and Italy, where the population is dense and the available space small. In the large cities of such lands, cities which have been populous for hundreds of years, it is not a matter of mere sentiment; it is a matter of almost life and death to the inhabitants. And few persons will, I think, deny that cremation will be eventually adopted in place of earth-burial. This on grounds which will suggest themselves to all. It was, in fact, Christianity that caused the reintroduction of earth-burial, for Christianity taught the resurrection of the body. This is the reason why the Churches have always opposed cremation. But it is seen now, apart from any theological argument, that there can not be a bodily resurrection, as the same particles of matter form, in the course of time, parts of various bodies, decaying nature ever springing up to blooming life.

The objects of interest lying about the funeral pyres and burial mounds of the human race in its long, long march are so

many and so full of interest that one knows not where or when to stop. There is the burial at sea—the most solemn of all—when upon the mighty ocean the little group gathers round the captain, and he commits the body to the waters until that day when "the sea shall give up her dead." There are the rare forms of funeral ceremonies; for, although the chief are those I have mentioned—earth-burial, burning, and embalming—yet these are not all. Some races merely expose the body without any protection, as some others actually put to death the aged and infirm. Strangest of all, the Parsees of India expose their dead to the fowls of the air on the Towers of Silence at Bombay, holding that earth, or air, or water may not be desecrated by contact with the lifeless body.

There are the great funerals of the world: of Alaric the Goth, the conqueror of Rome, who was inclosed in a golden coffin and buried in the bed of a river, which had been turned aside for the purpose and then turned back, those who knew the spot being put to death. Of Alexander the Great, from Babylon to Egypt, the grandest funeral the world has ever seen. Of Napoleon, the modern Alexander, when

> "Cold and brilliant streamed the sunlight
> On the wintry banks of Seine;
> Gloriously the imperial city
> Reared its pride of tower and fane;
> Solemnly with deep voice sounded,
> Notre Dame, thine ancient chime,
> And the minute-guns re-echoed
> In the same deep, measured time:
> While, above the cadenced cortége,
> Like a dream of glory flits,
> Tattered flag of Jena, Friedland, Arcola, and Austerlitz."

Of the good Queen Eleanor, wife of Edward the Confessor, that wife "whom living he had loved, and dead he had never ceased to love," and whose body the great king followed on foot from end to end of England, setting at each stopping place a cross, until he came to Charing Cross, in the very heart of London to-day, whence the body was borne to its final rest in England's mighty abbey. Of Israel's great leader on

> "Nebo's rocky mountain height, on this side Jordan's wave,
> Where, in the land of Moab, there lies a lonely grave;
> And no man knows that sepulchre, and no man saw it e'er,
> For the angel of God upturned the sod, and laid the dead man there."

Of Him who was laid in the rock-hewn tomb of Calvary, "the man of sorrows and acquainted with grief." Time does not permit us to dwell upon these, or upon the literature of the tomb—Longfellow's God's Acre, Gray's Elegy, Milton's Lycidas, and

scores of others. There is just one thought in conclusion. It is that the funeral customs of the world, although not a conclusive, are yet a very strong argument in favor of the belief in the immortality of the soul. For the impelling motive in all these customs has been that death does not end all, that there is a life beyond the grave. This it is which has prompted the savage to lay offerings on the grave, that the spirit may return and accept them. This it is which prompted the Egyptians to embalm their dead, that the earthly form might one day be reclaimed by its former possessor. This it is which has prompted the preservation of the body by secure burial, that it may not be consumed by wasting time. This it is which has inspired the burning of the body, that the soul may be free from its earthly fetters. Now, how are we to account for this worldwide belief? I mean, unless there underlies it a basis of fact. To have implanted this belief—unless it has a fact as a basis—would seem to be but mockery on the part of an all-wise, an all-good God.

POETRY AND SCIENCE.

By WILLIAM H. HUDSON,
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IN his able and suggestive essay on Cosmic Emotion, the late Prof. Clifford pointed out the significant fact that in the development of thought the feelings never quite keep pace with the intellect. It is not hard to see why this must be so. Every new achievement of science, every fresh acquisition of knowledge, makes its appeal directly to the intelligence; and the judgment so far as it is clear and unbiased, decides all questions at issue purely on the merits of the evidence laid before it. Any revision of old formulas, any restatement of old theories cause no friction, and are made as a matter of course. But meanwhile each such fresh achievement or acquisition enters at first as a disturbing factor into the emotional conditions of the time. Every generation finds itself in possession of a certain body of knowledge concerning the universe, and a certain philosophy of life based upon that knowledge; and between such knowledge and philosophy upon the one hand, and its average emotions upon the other, there is, as the result of long action and interaction, an adjustment or equilibrium which at the outset is relatively complete. The doctrines of Nature and human life in the midst of which men have grown up have become so familiar to the common mind that the feelings have had ample time to play round them, to saturate them, to make them their own. Presently a sudden discovery,

or the rise of a new hypothesis concerning the world, causes unlooked-for expansion of thought. Unknown aspects of the universe are brought to light, hidden processes revealed, undreamed-of conceptions introduced. What follows? The traditional balance between knowledge and emotion is disturbed. The intellect adjusts itself rapidly to the changed conditions; the emotions cling tenaciously to the conditions that are being left behind. Years, perhaps generations, have to go by before once more the intellectual possessions of the age are brought into sympathetic relation with its common feelings and aspirations, and the adjustment in this way approximately restored.

Illustrations of the principle here outlined may be found without going further than the experiences of our own lives. We all know well enough that at a time of great emotional stress or upheaval we tend to revert to those ideas of our earlier days which we fancy we have outgrown, and which in calmer seasons no longer have any hold upon us. This is so notoriously the case that much capital has been made in theological literature out of the undeniable fact that during periods of unusual excitement—during periods, that is, when the feelings take the upper hand—the most skeptical spirits are apt to be driven back from the open sea of doubt to the safe anchorage of their boyish faith. It is a trite remark, too, that long after the judgment has been convinced of some new proposition, the feelings will still persist in protest and opposition. "A man convinced against his will is of the same opinion still," as Hudibras long ago told us. Now all this, in view of our generalization, is precisely what we should expect. The feelings in most of us are very imperfectly adjusted to our new intellectual acquisitions and their philosophical consequences; hence, in times of crisis, the almost inevitable lapse into our older thought of the world, and our cruder guess at the riddle behind it. In other words, the most advanced thinker is likely to be more or less conservative upon the side of his emotions. And all this explains not only the conservatism of women and elderly men, but also the constant tendency among those engaged in the study of the problems of life to segregate into opposing parties, roughly definable as the theological and the scientific—those who, guided mainly by the feelings, resist the new knowledge of the age; and those who, looking at facts from the point of view of the insulated intellect, accept such knowledge, concerning themselves but little with the question of its emotional results.*

Now this generalization interprets for us certain well-known

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* A striking commentary upon these remarks will be found in the wonderful scene between Clotilde and Doctor Pascal in Zola's novel, *Le Docteur Pascal*, chap. iv.

facts that have found their place in the history of every great crisis in thought. The religious emotions of every epoch, though they have this of absolute and permanent about them, that they belong to man's sense of the mystery that lies at the heart of things, find their immediate and concrete expression in direct relation to what is currently known and thought of the world and of man's place in it. By and by Science steps in, and shows that the popular cosmology is childish, and the philosophic structure erected upon it a mere house upon the sands; and in the shock that follows it is not surprising that so many fine religious natures should feel themselves unhinged. The emotions have clung about the old knowledge so long that when that old knowledge is swept away they too seem in themselves to be hollow and untrustworthy, and a numbing sense of chaos and utter inanity settles down upon the consciousness of the world. This is the experience through which mankind has passed in every age of unusual intellectual movement and revision; this is the experience through which, in these days, we ourselves are passing. The wail of anguish that goes up to Heaven as foundations that have stood the test of centuries crumble rapidly away; the despair of many who, driven hither and thither by adverse winds of doctrine, know not where to turn for comfort or hope; the Cassandra cry of not a few who would have us believe that all faith has gone forever—these are simply signs of the times, unavoidable accompaniments of the wrenching away of men's emotions from their old moorings under the pressure of that extraordinary influx of new ideas that characterizes the age in which we live. The progress of science during the past half century has been so rapid and continuous that the intellect has got a long way ahead of the feelings, and the world is overweighted by a large body of unemotionalized knowledge. This is the real meaning of our present predicament in thought. Only hereafter can dawn the epoch of readjustment between feelings and knowledge; only after many years of such ferment and commotion can men at last come to the understanding that the new thought, too, is religious and poetic, and will furnish a soil for all the higher emotions richer and more fertile than that which the deluge has overflowed.

The poet, more sensitive than other men to the subtle influences at work around him, finds himself in the storm and stress of such a transitional period adrift amid currents and countercurrents of thought, the trend of which is only dimly foreseen or guessed at by the scientists and philosophers themselves. He moves about "in worlds not realized," with many "blind misgivings," and much painful groping toward the light. Now, whatever else poetry may or may not be, and whether we define it, with Aristotle, as an imitation or, with Bacon, as an idealization

of the actual world around us, it is unquestionably the expression of an attempt on the part of the mind of man to deal with life from the standpoint of the feelings. It has been well said that while science is concerned with the study of the relations of things among themselves, religion and poetry are concerned with the study of the relations of things to us. This gives us the poet's problem. Regarding the new thought through the medium of the imagination, he has to inquire in what way and to what extent the changes in our conceptions of the universe and man brought about by science affect our emotional outlook—our feelings respecting our own individual lives, our sympathies with the lives of others, our attitude toward Nature, our hope for the future of the race here and of the individual hereafter.

What, then, will be the poet's response to the intellectual conditions under which he lives? Confronted as he is by this large mass of unemotionalized knowledge, what will be his message to his time? It may be one of passionate protest against or obstinate indifference to the revolutionary movement in progress around him, and which may seem to him to be taking all the charm from life, all the beauty from the world. It may be one of simple doubt and hesitation; a mere cry of Why? and Whither? —not so much an answer to the mute questionings of men, as a translation of those questionings into language and form. Or, in the third place, it may be a glimpse of coming things—an attempt to catch the new thought and force it to an emotional revelation. And as no man can wholly exclude the "element of necessity from his labor," or "quite emancipate himself from his age and country," * so in one or other of these three ways will the forces of the time influence and fashion the poet's work. His attitude will thus be one of reaction, of uncertainty, or of prophecy; his gospel a gospel of evasion, of skepticism, or of promise.

Hereafter I hope to sketch the history of the poetry of the nineteenth century from the point of view now indicated—that is, to study it in direct connection with the scientific and industrial movements of our time. Here, in the illustration of the above theory, I must content myself with the mention of a few typical names.

For the most distinctive example of the poetry of evasion we turn naturally to the pages of John Keats. Leave out of question the artistic qualities of his work, which have absorbed most critics, but which do not concern us here, and the most significant thing about Keats is his absolute indifference to the life and spirit of his time. The world about him was alive with fresh interests and hopes; watchwords of progress were in the air he

* Emerson, Essay on Art.

breathed; almost all his great contemporaries—Wordsworth, Coleridge, Shelley, Byron among the number—were more or less drawn into the eddying current of change; but Keats remained an outsider and an alien. He felt no thrill of enthusiasm for the development of knowledge and the march of the race, no young man's interest in the world's travail and hope. He never troubled himself to ask what direction the thought of the time was taking. He only knew and only cared to know that it was drifting in some direction away from the old landmarks that he loved so well, and he persistently resented the change, without, perhaps, even realizing what it actually meant. There was nothing, therefore, left for him, as he felt, but to emulate the "negative capacity" of the Elizabethans—to live in the midst of all this ferment without being touched by it.* So he built for himself a palace of art—"a lordly pleasure house"—and escaped through the imagination from the pressure of a world in which he had no part.

For Keats, then, knowledge emphatically meant disillusion. Reality, romance—these were essentially contradictory terms. To explain the processes of Nature was to remove them once and for all from the soft twilight of poetry, through which they loomed dim but beautiful, into the lurid white glare of actuality, where they stood out gaunt, naked, revolting. The sense of real things constantly present to break in upon his sweetest fancies, he could liken only to a muddy stream, the turbid current of which was forever sweeping his mind back to darkness and nothingness. In the well-known passage in Lamia about the rainbow, with its emphatic protest against philosophy, we have the man's horror of science, so frequently revealed elsewhere in his work by implication, set forth in a kind of formal declaration. Such an outburst inevitably reminds us of the diatribes in Mr. Ruskin's Eagle's Nest against physiology and what he calls Darwinism—perhaps the foolishest utterances to be found anywhere in his voluminous writings, which is itself saying a good deal. But, after all, perhaps the best commentary on the lines in question is Haydon's statement that, three years before Lamia saw the light, Keats and Lamb, while dining with him (Haydon), had agreed together that "Newton had destroyed all the poetry of the rainbow by reducing it to the prismatic colors." We may imagine how these two sage critics would have laid their heads together over the more modern legend of the cynical chemist who is said to have remarked that a woman's tears had no longer any kind of power over him, since he knew their precise constituent elements—muriate of soda and solution of phosphate! Clearly, the æs-

* See his remarkable letter to his brother, on Shakespeare's "negative capacity," in Forman's edition of Keats's works, vol. iii, pp. 99, 100.

thetic emotions of Keats lagged far behind the intellectual achievements of his time; and it was the consequent maladjustment that caused him to cling so persistently to that old order of ideas, to that cosmology of marvel and catastrophe which he felt to be slipping away from the world with all the beautiful accumulation of legend and myth which in the course of many centuries had come to cluster about it. To him "glory and loveliness" had indeed "passed away" from the present, and could be sought only in the things that the general world was rapidly outgrowing; and hence it was to these dead things alone—to Greek fable or mediæval story—that he could turn to find the beauty that was to be to him a joy forever.

But though in Keats's day the ocean of knowledge was slowly rising on every side, he had no hint of that great tidal wave of new ideas which has carried us so rapidly forward with its resistless roll. It is little to say that during the past half century the consequent emotional perturbation has been greater than the world ever experienced before; for the single generalization of evolution has disturbed the equilibrium of which we have spoken to an extent hitherto undreamed of. We face the universe from a new standpoint; our relations to Nature are altered; the problems of life, so often analyzed, so much discussed in the past, meet us in unfamiliar forms. Amid the Babel of tongues and the fierce clash of ideas and purposes to which all this has given rise, the poetry of evasion has still made its voice heard and its influence felt. In the works of Rossetti and the earlier writings of William Morris (The Earthly Paradise and the other poems antedating his conversion to socialism) we have the artistic traditions of Keats carried on with unmistakable success; the mediæval mood and attitude, however, replacing the pagan mood and attitude of the earlier bard. Both these men, too, sought to make their escape through the imagination from the life of their own time—from the rapid material changes going on in every direction, and from the speculation and inquiry with which the whole air is alive. The prelude to The Earthly Paradise, taken even by itself, makes Morris's position sufficiently clear, and to understand Rossetti's we have only to remember his own declaration of his belief that it concerned men and women far more to attend to the form of their tables and chairs than to bother about the doctrine of the conservation of energy and the hypothesis of natural selection.

Meanwhile, in the early years of the modern upheaval, a note of deeper meaning made itself heard—the outcry of earnest natures, conscious of the breaking down of old standards, but doubtful as yet of the spiritual import and tenor of the iconoclastic forces at work. To turn from the poems of Keats, Rossetti, and Morris, to the poems of Arthur Hugh Clough and Matthew

Arnold, is to turn from the poetry of evasion to the poetry of skepticism. Here we find, as the burden of all their song, not the reactionary indifference of the simple artist, but the eager probing of the inquirer. Clough and Arnold are modern men, standing face to face with the problems of modern life. There is in their works no hatred of the new knowledge for itself, no intellectual cowardice regarding it; on the contrary, every fresh insight into the methods of Nature and the laws of life is welcome; but there is, at the same time, painful realization of the fact that the old foundations of the emotions are being sapped and undermined. What will be the result? Will science in this respect prove constructive as well as destructive? Will new emotional bases be given in place of those swept away? Or, will all the immemorial desires and aspirations and spiritual cravings of humanity be left to perish in grim despair before the blighting breath of a crass materialism which recognizes no sanctities and holds out no hope? These are the stubborn questions which, in one form or another, are put again and again, and for the most part left unanswered, in the poetry of the men to whom we now refer.

Clough's poetry, though little read to-day, and lacking almost every element of popularity, is of the utmost interest for those who care for the study of literature from the point of view here adopted. It was with little exaggeration that Mr. Lowell adjudged him the man who most probably "will be thought, a hundred years hence, to have been the truest expression in verse of the moral and intellectual tendencies, the doubt and struggle toward settled convictions, of the period in which he lived." He was the plaything of conflicting tendencies, which he saw he could not harmonize. Everywhere in his poetry the striving after truth is accompanied by a distressing realization of emotions out of touch and keeping with his intellectual environment. "What I mean by mysticism," he writes in one of his American letters, "is letting feelings run on without thinking of the reality of their object, letting them out merely like water. The plain rule in all such matters is, not to think what you are thinking about the question, but to look straight out at the things, and let them affect you." This is the sane utterance of a manly nature, alive to the manifold dangers of unchecked speculation, and not to be deceived by theological or metaphysical jugglery into any false sense of security. To hold fast to reality—that he saw was the prime requirement, to be fulfilled at any cost; and to seek for emotional excitation in what has been proved to be no reality, but a figment or shadow, would have seemed to him the willful blindness of folly or the despicable subterfuge of cowardice. But was the reality itself capable of furnishing scope for that emotional satisfaction which his nature demanded? Sometimes with more, sometimes

with less of hope, he approached this obstinate issue; but the answer of the sphinx was still, as it were, couched in riddles. Thus his message to men was almost always a message of moods; brief seasons of faith alternating with other seasons in which the sense of loss was so strong upon him that he was tempted to struggle to save some floating remnant, worthless though it might turn out to be, from the universal wreck of belief that was going on around him.

An equally characteristic and far more considerable exponent of this attitude and mood of mind was Clough's friend Arnold. It was his mission, too, to give poetic voice to the emotional restlessness and craving which—inevitably as we now see—went along with the intellectual progressiveness of his age. Arnold (whose verse and prose, earlier and later, treatments of these themes furnish subject-matter for most instructive contrast) has given us the key to his position, while at the same time he has shown us how acutely that position was realized by him in the familiar lines in the splendid Stanzas from the Grande Chartreuse, in which he describes himself as "wandering between two worlds, one dead, the other powerless to be born." The old faith had gone with the old theories of the universe and man, and the new theories of the universe and man had not yet revealed themselves in a religious light, or even shown themselves capable of such revelation. For the time being they were hard, dry facts of science merely; that they would ever be more than this was far from clear. Hence "the hopeless tangle of the age," the "strange disease of modern life," the sense of futility and despair, so characteristic of the large body of his poetic work. In the wonderful poem just above referred to—a poem that can hardly be read too often or too carefully as an exposition of the spiritual conditions of the man and his time—all this is made particularly clear. Why does Arnold linger among the shadows and traditions of the old Carthusian home—he a skeptic of the later time? Because he is seeking sadly for the spiritual comfort which all the while he knows he can never find, either in the old creed, because he has intellectually outgrown it, or in the new, because he has not yet emotionally appropriated it. Thus he must let the world go its way, with some hope for the coming race of men, perhaps, but for himself and his own time, none.*

For Clough and Arnold, then, knowledge and feeling were out of harmony; yet at times they seem to have caught glimpses of

* The skepticism of Arnold and Clough is to be found deepened to absolute despair in the works of many of the minor verse-writers of the time—as notably in that superb expression of pure pessimism—The City of Dreadful Night. But conditions of space forbid my following the matter into these further details.

the possibility that the disturbance of relations from which they suffered so keenly might ultimately be overcome. That the far-off future might at length bring "a solemn peace of its own"—this in serenest hours was their larger faith. Fortunately for the world, stronger poetic voices were already making themselves heard in the declaration that the epoch of readjustment might haply be near at hand. While some men were busy railing at the new science as dismal, prosaic, irreligious, and others were painfully asking whether, real and certain as were its revelations, they could ever come to mean anything to the soul of man, there were still those who, with greater receptivity and more prophetic vision, saw that the new science itself, when once sympathetically envisaged, could even perhaps for this generation provide the spiritual impulses, the religious and poetic fervor, which the old knowledge, with the philosophy of life belonging to it, had furnished for the generations gone by.

The mass of men, let us repeat, can only achieve this readjustment of their feelings to their knowledge, this emotionalization of newly acquired fact, by a slow and painful course of adaptation. The discoveries and inductions of science must grow familiar through habit and association before they can take a poetic or religious coloring for the average mind. But it is exactly here that a great poet's best work may be done. He can lead the way. Taking the generalizations of the scientist and the philosopher as they stand in exact and unimaginative statement, he may illumine them with his genius, and as he sets them in their proper light and pierces into their inner natures, the world, for the first time begins to apprehend their beauty and to seize their spiritual meaning. It is then that men are thrilled, as Emerson puts it, by the influx of a new divinity upon the mind. It is, in a word, his special mission and privilege to stand forth as the emotional interpreter of the intellectual and material movements of his age.

Hence arises the all-important question, Does our modern poetry show any tendency toward the absorption into itself of this vast mass of unemotionalized knowledge by which we now stand confronted? It is manifestly too early as yet to expect any full emotional development of this new material, but are there signs of a movement in this direction? Can we yet pass from the poetry of evasion and the poetry of skepticism to a poetry that we may fairly call the poetry of promise?

The name of Tennyson inevitably presents itself in this connection. In the writings of this poet—the last of the true Victorian brotherhood—we find, it need hardly be said, the sad, skeptical note of Arnold often enough repeated. Not planting himself, as Browning did, upon the strong rock of a transcen-

dental philosophy, he was shaken by storms of doubt and difficulty that seemed to have nothing but a tonic effect upon his more robust contemporary. Struggle, uncertainty, hesitation are revealed throughout the whole of his work; he holds his faith with infinite effort; even In Memoriam, as he told Mr. James Knowles, was more sanguine than the man himself; and he got but little beyond a "faint trust" of "the larger hope." Yet there are other sides to Tennyson's writings that reveal the man in a very different light. His keen interest in science; his sympathetic hold upon the vast movements in progress around him; his manly attitude toward the changes that life and thought were everywhere undergoing; his reiterated belief that we are but in the morning of the times—the "rich dawn of an ampler day"; his faith, only now and then shaken, in the years that are still to come—all these characteristics combine to render Tennyson the most intensely modern of all our modern poets.

> "Let knowledge grow from more to more,
> But more of reverence in us dwell,
> That mind and soul, according well,
> May make one music, as before,
> But vaster."

There is the very index to Tennyson's intellectual position. And a very casual reading of his collected works will suffice to show how large an expression many of our new scientific conceptions find in his utterances. The underlying principle of all our modern thought—the doctrine of the universality of law, and of that orderly progression or development within the domain and under the influence of law which we call evolution—these principles constitute the firm foundation of the entire fabric of his philosophy of life; they characterize his attitude toward the external world; they mold all his social and ethical teaching; out of them grows his faith in the destiny of the race, his hope for the untried future. For him, man is as yet "being made"; the "brute inheritance" clings about him; but, because so much has already been accomplished, much more will be accomplished by and by.

> "This fine old earth of ours is but a child
> Yet in the go-cart. Patience! Give it time
> To learn its limbs. There is a hand that guides."

Above all things, it seems to me significant that, with all the reaction against the cry of progress that undoubtedly marks some of his later poems, the evolutionary note comes out with ever-increasing strength to the very end. It should not be forgotten that such poems as The Dawn, The Dreamer, and The Making of Man all belong to his last published volume.

To go into further detail would be impossible; limits of space are already exhausted. Passing reference only can be made to the fact that, while in Tennyson's works, upon the whole, we find the fullest poetic interpretation as yet given to modern thought, writers like Browning, Whitman, and Emerson, and among those still living Robert Buchanan, William Watson, and Mathilde Blind, have each of them revealed in different ways a healthy tendency on the part of poetry to look at the facts of life from the point of view of present thought rather than from the point of view of past thought, and to recognize the supreme fact that if we find cause to complain, with William Morris, of the emptiness of our own life, it is the fault of ourselves and not the fault of our times. But here the subject must be left for the present; and the discussion of many important questions arising in connection with the above-outlined theory, held over till a more convenient season. Enough, perhaps, has been said to indicate the view we have been trying to develop of the relations of poetry to science, to show that there is no essential antagonism between them, and to point out that recognition of the one as the supplement of the other does not at all imply, as is so often thought, any absurd confusion of their methods and aims. For myself I read without fear the French critic's prediction that fifty years hence no one will care to read poetry. "Of all forms of mistake, prophecy is the most gratuitous," says George Eliot, and such a statement may be quietly disregarded. On any large principle of education, poetry has its secure place in the scheme of life; but our emotions must respond to our knowledge, not our knowledge to our emotions. The business of the poet in his capacity of spiritual teacher is to help us to clothe fact with the beauty of fancy; not to try to force fancy into the place of fact. Let us understand what is scientifically true, socially right, and our feelings will adjust themselves in due course. It is for science to lead the way, and the highest mission of the poet is ever to follow in the wake, and in the name of poetry and religion claim each day's new thought as his own.

The locality of Florissant, Colorado, a lake deposit of the geological age called Oligocene, is famous for the extraordinary abundance and variety and the excellent condition of its insect remains. No group of insects perhaps, according to Mr. Samuel H. Scudder, shows this more strikingly than the family of "crane flies" or "daddy longlegs." Several hundred species have been collected there, and in a very considerable number of them, representing many species, the venation of the wings is completely represented with all their most delicate markings, and also the slender and fragile legs with their clothing of hairs and spurs, and, to some degree at least, the antennæ and palpi. Even the facets of the compound eye are often preserved as in life.

ASTRONOMY OF THE INCAS.

By M. JEAN DU GOURCQ.

THE traveler who in these days penetrates to the high plateaus of upper Peru and Bolivia, explores the basin of Lake Titicaca, and returns to Cuzco, is struck with the great number of ruins, hieroglyphic inscriptions, broken pottery work, and *huacas* which he meets at every step. They are the relics of the fanaticism of the conquerors and of their unbounded rapacity. Of the magnificent palaces adorned with gold and silver, the temples of the sun glistening with jewels, and the astronomical columns which stood at all points in the country from La Paz to Anito, there remain nothing but fragments of crumbled walls, an infinite number of pieces of bricks, deformed and mutilated statues disintegrated by time, blocks of granite and basalt standing in the deserted fertile lands like black ghosts, and at long distances apart a few tombs which have been forgotten by the Spaniards. The monuments standing at Tyahuanaco and on steep hills difficult of access, and in the archipelagoes of Lake Titicaca, although dilapidated and also victims of the hands of iconoclasts, deserve serious attention on account of their relatively good state of preservation.

Popular superstition has, furthermore, contributed no little to preserve the ruins of Lake Titicaca from complete spoliation.

Why are not more pains taken to send out scientific expeditions to these regions, to study the ancient civilization of the Incas? A work might be undertaken there of like nature with that which has been accomplished in Egypt by Champollion and Mariette Bey. Much that is valuable has been done there, it is true; but the whole story is still far from being told, and I am confident that *huacas* have many secrets and surprises in reserve for us. The astronomy of the Incas, a curious side of Peruvian civilization, while it has been lightly touched upon by some of the American reviewers and superficially noticed by a few explorers, is yet almost wholly unknown to us. Some even, of whom Mr. Wiener is one, have gone so far as to deny that astronomy existed among these peoples, or to reduce it to simple rudimentary notions. Yet we have only to keep our eyes open in passing through the country, or to consult the contemporary annals of the conquest, to be assured that their science was not a mere chimera or a legend invented to amuse. It would be strange, indeed, if a people whose only cult was the worship of the stars had not been moved to study the nature, movements, and phenomena of the heavenly bodies, and had not attempted to explain them in some way.

The proofs that the Incas . . . had a real system of astronomy are scattered, partly in what remains of the monuments that were consecrated to the sun, and partly in the accounts of historians—accounts which, whether because their importance has not been suspected, or because of the difficulty of quoting them, most of them having been printed only once, others having remained in the state of manuscript, and very few of them having been translated, are but little known to men of science. Whatever the verity of the legends preserved in these accounts, we find a comparatively highly developed astronomical system among the Incas, of which the most interesting parts are here given from rare documents already published, and from American manuscripts and traditions. The work has not before been done so completely.

Six nations only—China, Mongolia, India, Chaldea, Egypt, and Australia—had, before the discovery of America, divided the visible celestial sphere into constellations, and had used figures of their own invention to represent them. The Peruvians, although situated at the meeting of the Northern and Southern hemispheres, did not extend their division over the whole sphere; they recognized and studied only a few of the more brilliant constellations, like the Pleiades, the Jaguar, the Standard, the Southern Cross, and some other groups which have not yet been identified.* It is probable that they extended this division further than the first historians—who were not learned in astronomy, and could therefore pay little attention to all the details—represent. Later writers speak of other constellations which they do not mention. The Incas called the milky way the dust of stars, and gave names to its different parts. What is now called the Coal Sack was figured by them as a doe suckling her fawn—a simple and poetic transformation of the Grecian and Aryan legend of Hercules and his nurse.† A few stars of the first magnitude, such as Capella and Vega, had special names.‡ It is almost impossible that the Incas should have failed to give distinct names to the splendid stars of the Southern hemisphere, such as Sirius, Canopus, Achernar, etc. The silence of historians respecting this point is far from being conclusive, and may be accounted for by supposing that many of these stars not being visible in our hemisphere, they did not ask the natives for their names, and limited their inquiries to the stars of the Northern hemisphere which they knew.

The only planet which the Incas had discovered was Venus, which they called the hairy, on account of the brightness of its

* Acosta, Histoire des Indes, 1591, Book V, chap. iv.

† Garcilaso, First Part of the Royal Commentaries, 1609, Book II, chap. xxiii.

‡ Acosta. Cælius, Cælum astronomico-poeticum, 1662, chap. xix.

rays. They said that, being the most brilliant of the stars, the sun would not permit it to be separated from him, and obliged it to attend his rising as well as his going down, just as at the courts of kings only the most distinguished lords and the handsomest ladies were admitted to the ceremonious royal risings and retirings. It appears nearly certain that the Incas spoke of Venus under two different names, according as it preceded or followed the sun. To this day the native Peruvians name it, in fanciful language, the eight-hour torch and the twilight lamp. As this star served to show the Indians when it was time to prepare the maize for cooking, they also gave it a name indicative of that act. A chapel in the Temple of the Sun was consecrated to this planet.

The phases of the moon were well known to the people, and they attributed life and movement to it. When the moon was invisible, during the days preceding the first quarter, they said it was dead, and would rest three days in the tomb, beyond the snowy mountains and the immense ocean. Then it would rise again, to their great joy. To the people of Asia and North America the spots on the moon represented a rodent—a hare or rabbit—or a human being. The Incas perceived in it a young woman, and said that once upon a time the daughter of the king, walking in the light of the moon in one of those limpid and blue nights peculiar to the tropics and to these latitudes, suddenly fell in love with the star of the night. Desiring to possess him, she went and hid herself in the top of a mountain by which he would pass, sprang upon him at a favorable moment, and became one body with him.* The moon, called by names which signified sister or wife, was regarded as the first wife of the sun, and was represented by a silver plate bearing a woman's face. It, too, had its sanctuary, occupying a station of honor in the temple of the supreme god.

The difference between the seasons not being distinctly marked in Peru by variations either in moisture or temperature, it was important to make very careful observations in order to determine the times for planting and harvest. The only method was by experiment. The attention of the ancient Peruvians was particularly directed to the time when the sun passed the zenith, for then it cast no shadow at noon. They also observed it very carefully at the June solstice when it was seen nearest to the horizon; and they succeeded, as we shall see, in giving their observations scientific precision.† The solar spots had also been observed.

In explanation of the circular motion of the sun, the Incas said that it was hung in space by a cord; that it entered the sea in the

* Garcilaso.

† Montesinos, Antiques Mémoires du Pérou, Book II, chap. ii, in manuscript at the Library of the Academy of History, Madrid.

evening, passed under the earth, and reappeared twelve hours afterward in the opposite part of the horizon.

The god himself was represented in sculpture, according to M. Wiener, in statues of gold or reddish-brown porphyry, with "his forehead encircled by the royal fillet in the midst of four fabulous animals moving around him." The same author, on the evidence of some monuments resembling the menhirs of the Druids, gives another explanation of the circular motion of the sun. "It is regarded," he says, "as a being which comes to rest at night after its daily march, in the inaccessible inclosure of the sanctuary (called by a Quichua term signifying the place to which the sun is attached). The holy object consists of two granite blocks about a metre in height, on the inner faces of which have been found holes about fifteen centimetres deep and nine centimetres in diameter." This was narrow quarters for a star as voluminous as the sun! We shall find further on that M. Wiener gives the same name to a system of observatories. The illustrious Peruvianologist has confused this word with the identical one which represents the year in the Quichua language.

The earth was believed to be flat and circular, and the center of it was shown in the sanctuary of Cuzco, the name of which, according to Garcilaso, signifies umbilicus, or navel. The Greeks had a similar belief, and located the center of the earth in the Temple of Apollo, another solar deity, at Delphi, which they called Ὄμφαλος, the navel of the inhabited world. It is celebrated under that title in some of the Pythian odes of Pindar. The earth, the Indian name of which signified "everywhere," was the only one of the stars that had no sanctuary in the Temple of the Sun. Like the peoples of the Aryan race, the Incas did not suspect that it was endowed with motion. Only the revolution of the stars existed to them; and the earth, instead of being a planet suspended in space, gravitating round the sun, and turning upon itself, was supposed to be fixed in the midst of a moving celestial sphere.

When the moon was eclipsed the Incas supposed that it was ill, and uneasiness prevailed whenever it appeared obscured. If the eclipse was total, they supposed that the star was perhaps dead, and that, not being capable of maintaining itself in space, it would fall to the earth, crushing the poor mortals thereon and that the world would come to an end. For this reason when an eclipse of the moon was beginning—an event they were not able to predict—the Incas with such instruments as were within their reach—drums, trumpets, cymbals, etc.—made a frightful noise, and, tying up their dogs, tormented them so as to extort the most hideous cries from them, in the hope that the moon, being a friend of dogs, would be softened by their howling and try to return to life. Men, women, and children joined with their princes

in conjurations to avert the catastrophe. As long as the eclipse continued they kept exclaiming, "*Mama-quilla, Mama-quilla!*" which might be paraphrased, "God save us!" and they supplicated the sun to aid them. After the eclipse had passed away they sang in chorus the praises of the god Pachacamac, who had cured the pale star of night. Garcilaso adds to this story that these practices were all still in vogue in his time—that is, a half century after the conquest.

Mention is made in the Memoirs of Garcilaso of a comet which appeared at the time of the death of the Inca Huascas, and of another which was visible some time afterward, while Atahualpa was a prisoner of the Pizarros. These apparitions were regarded as annunciations of imminent woe. So, likewise, were shooting stars, of which an extraordinary fall took place during the reign of the same Inca.* Montesinos speaks of the appearance of two comets during the reign of Yupanqui—one had the form of a lion, the other of a serpent. "The sun," he wrote, "had sent these two animals to destroy the moon. So the Indians directed a hailstorm of stones at the lion and serpent to veil their light and prevent them from tearing the moon to pieces, for if they succeeded in carrying out their purpose everything on the earth would be changed into savage and hideous beasts, women's hair into vipers, and other things into bears, tigers, and similar evil creatures." The Indians still believe that the shooting stars drop from the sky, and utter prayers for deliverance when they see them.

The Inca year was originally divided into twelve lunations, each of which had its special name. But experience having shown that this lunar year was ten or twelve days shorter than the solar year, a reform was determined upon. Montesinos asserts that an assembly of *amantas* in the reign of Agay Manco thoroughly rearranged the calendar, dividing the year into three months of thirty days each, and the month into three weeks of ten days each, and adding to complete the solar year a half week of five days, which was made six days every fourth year. The Inca Yahnar Huquiz, grand astronomer, soon discovered that an error of one day would appear after four hundred years in the calendar thus instituted! The Indians reckoned time by this system till the Spaniards came.† Garcilaso says that the Inca Tapac Yupunpuy discovered, three centuries before the conquest, that the period between the solstices was three hundred and sixty-five days and a quarter, and that he caused the intercalation of ten days and a quarter, distributed among the lunations, in order to make the lunar and solar years agree. Is it not strange to see the Gregorian calendar invented and applied by the Incas three hun-

* Garcilaso, Book I, chap. xxxiv.

† Montesinos, chapters xi and xii.

dred years in advance of the Europeans? The year was called by a name derived from a Quichua word signifying *to bind*, and the half century of fifty years was figured by the hieroglyph of a bundle of reeds tied with a ribbon. Each of the twelve months was named after its principal festival.

In the month of December a peculiar dance, in which only men participated, was performed with great solemnity on the plaza in front of the Temple of the Sun at Cuzco. Offerings were made to the divinity of lamas, which were burned on pyres of odorous woods; and birds and various animals, but rarely human victims, were sacrificed. The dances followed, representatives of all the provinces taking part in them. These dances were instituted by Huayna Capac, the twelfth Inca. Two or three hundred men, holding one another's hands, executed a kind of farandale, stepping in concert two paces forward and one backward, so that they constantly gained ground, and all the time singing of the exploits of the Incas. Huayna Capac had a golden chain made which they all took hold of. It was as long as the two plazas of Cuzco, and was composed of rings of the diameter of the sun. The Indians hid it carefully at the time of the arrival of the Spaniards, and a legend relates that it was thrown into the depths of Lake Titicaca. The young Incas appeared at this festival, according to the expression of the historian Balboa, as armed knights. The sages charged with their education prepared them for the solemnity by scourging them with leaves and rubbing their figures with the blood of the offered lamas. The blood of the lamas and other victims also flowed in January, February, March, and April. The feast of the corn harvest was celebrated in May, and was held in the Gardens of the Sun, on the hill *Colcampata*. The people intoxicated themselves with a fermented drink (*chicha*), made from corn and fruit, and danced in masquerade.

For the June festival, which was dedicated to the sun, rude statues of men and women were made and covered with rich vestments. The courts of the temples were strewn with flowers, and the reigning Inca, with the chiefs of the tribes, executed sacred dances. The feast of the Pleiades is still celebrated in this month. In July and August spotted lamas and pigs were sacrificed, as an offering to obtain abundant crops.

The vernal equinox was celebrated in September. All the idols were collected in one place previous to the rising of the moon. As soon as the star appeared above the horizon the Indians uttered loud cries for the aversion of harm, and struck one another with whips of burning straw; washed in a running brook; and, on their return, sacrificed a hundred white lamas. They kept intoxicated for four days, and ate cakes prepared by maidens with the blood of the victims. Another hecatomb was

offered in October, and in November the princely youth who were to be given arms in the next month had their ears pierced.*

These Peruvian ceremonials were very like those which Ovid has described. They were not the only ones; an edict of the Inca Pachacutec mentions three regular festivals occurring in each lunar month; there were also days for fairs and markets, and a rest day occurring every nine or ten days, like the *nondines* of the Romans, but not corresponding either with the quarters of the moon or the week, although the phases of the moon were well known to the Incas. As their lunar year fell behind the true time, they rectified their calendar constantly, trying to make it conform roughly with the phases of the moon.

The hours were not determinate spaces of time corresponding with a mathematical division of the day, but simple indications of such conditions as dawn, or morning, noon, sunset, and night.

The astronomical observations of the Incas were at first very elementary and empirical. They marked the day when the sun passed over the zenith. An experiment of the simplest character will be sufficient to account for the conclusions they drew from this observation. If we plant a stick vertically, and observe the shadow which it casts when shone upon by the sun, we shall find that at noon toward the end of December, this shadow is very long and directed toward the north; then it diminishes gradually till the day when it is shortest at noon. In the Southern hemisphere the shadow follows an inverse direction to this, and is longest at noon in June and shortest in December. The days when the shadow is longest, beyond the tropics, are the same for all places in the same hemisphere. But the days when there is no shadow at noon are not the same for all latitudes in the same hemisphere within the tropics. A day's difference exists for every forty kilometres. For this reason the Incas established observations at different distances from north to south, over the whole extent of their empire.

In order to verify the equinoxes, the *amantas*, or astronomers, arranged richly sculptured columns in the courts of the temples of the sun. On the approach of the equinox, they observed the shadow projected by the columns. These were placed in the center of a large circle through which a line, exactly oriented by experiment, ran from east to west. When they saw that the shadow struck this line in the middle, and that at noon the column was bathed with light on every side, they announced the equinoctial day. They then adorned the columns with flowers and fragrant herbs, and brought offerings of gold, silver, precious stones, and fruit to the god. The *gnomon*, or column, was surmounted

* Desjardins.

by a throne of massive gold, in which the sun was to come and sit on that day, illuminating the tower on all sides.

The *amantas* perceived that only four moons passed when the shadow was turned toward the north, while there were eight moons when it was directed toward the south. They did not take into account that their observatories were situated between the equator and the tropic of Capricorn. But when the Incas had established their residence at Quito, their men of science immediately remarked that the two shadows were equal, and that the duration of their variations was exactly six moons. This is why the columns called equinoctial at Quito were especially venerated as the favorite abode of the great divinity.

Mr. Wiener mentions another astronomical apparatus which was intended for the precise verification of the time of the equinoxes: "A vertical well, dug mathematically in the line of the zenith, twice a year, in spring and autumn admitted the rays of the sun and gave light in its lowest depth to a vast tunnel over which it was bored. These observatories were called *intihuatanas*. These *intihuatanas* were doubtless real, but the assignment of such a purpose to them was a work of pure imagination." This apparatus, ingenious as it may have been, is too sensibly removed from historical tradition and from the study of the ruins of the solar temples to have really existed. It should further be remarked that such an observatory could be mathematically of service only for the September equinox.

In tracing the meridian the Incas appear to have limited themselves to raising a pillar perpendicular to the line which the shadow follows on the day when the sun passes the zenith, and that they reached this result by a series of trials. This accounts for the variations of a few minutes offered in the orientation of some of the monuments.

The Inca method of determining the solstices was very striking, and nothing like it is found with any other people. On this interesting point we can not do better than literally translate Garcilaso, a descendant of the Incas by his mother, who was better informed upon it than any other writer: "The common people counted the years by the crops, and all were acquainted with the summer and winter solstices. They have left conspicuously visible marks of them. There are eight towers which they constructed at the east, and eight others which they constructed at the west of the city af Cuzco, arranged in fours, of which two, smaller than the others and about three stories high, were placed between two others much larger. The other two towers were much higher than those which in Spain serve as lighthouses in the seaports and as observatories on the frontiers. These were intended for the astrologers, to give them a good view. The spaces

between the smaller towers, being illuminated by the rising or setting sun, were for the solstices, and the towers on the east answered to those on the west, at the winter or at the summer solstice. In order to verify the event the Inca placed himself in a convenient spot, whence he watched whether the sun rose or set between the two small towers on the east and on the west, and thus the most skilled of the Indians found the astrology of their solstices.*

This description, equally naïve and unintelligible, requires some explanation. The towers and turrets went by fours, two large and two small, and there were two systems, intended for the observation, by one system of the winter solstice, by the other of the summer solstice. In position and relative distances they were so arranged that when the sun reached the tropic of Cancer the shadow cast by the northeastern turret was exactly tangential, at the moment of sunrise, to the southern face of the northwestern turret, and at the same time hid the sun from the *amantas* on observation in the corresponding tower; and *vice versa* at the moment of sunset. As the sky might be cloudy at sunrise, the astronomers posted to observe the setting sun replaced, confirmed, or rectified, when necessary, the determinations of the morning. The southern turrets were used in the system of observatories for the summer solstice.

Montesinos gives another version which seems different when taken literally, but substantially confirms the former. He relates that the Inca Capac Raymi assembled his learned men and astronomers to find the solstices. "There was a kind of solar quadrant formed by shadows, and with it they knew what day was long and what other was short, and at what time the sun went toward the tropics and returned from them. I saw four very ancient walls on a hill, and a son of the country affirmed to me that this building had served the ancient Indians as a clock." Though precise for that time and place, and quite original, no account has been taken in this method of the change in the obliquity of the ecliptic, forty-eight seconds a year, according to Delambre, the effect of which upon the azimuth is very sensible in those latitudes. Houzeau says that the Incas had no idea of this displacement; that they observed the June solstice only, and that the continued observations of the *amantas* proved the absence of a solar calendar. It is very possible that the Incas perceived that their observatory system finally became useless, and that, without stopping to inquire into the reason, they constructed new ones. There is no doubt that the Incas recognized the movement of the ecliptic some time before the other people of the Old World, but without

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* Garcilaso, Book II, chap. xxiii.

comprehending it, without making the necessary deductions for it, and without including the important phenomenon in their calculations. Houzeau was mistaken in affirming that the Incas observed only one solstice. The historians are unanimous in describing a festival for each of them. We have seen, besides, that two systems of observatories existed, with towers and turrets in different positions, and consequently designed for the observation of two different solstices.

We need not, furthermore, presume that the people had no calendar, from the *amantas* observing the zenith passages of the sun every year. The day, hour, and minute of an eclipse are foretold now; yet astronomers are not prevented by this from studying the different phases of the phenomena.

The destruction of these observatories, which Garcilaso says were still standing in 1560, must be regretted. Those of Quito were destroyed by Sebastian Belalcazar, under pretext that they prompted the natives to idolatry. Only shapeless ruins of them are now to be found. The best preserved ones are at Cuzco, on the Carmenca hill. The question, long asked, whether the Incas used optical instruments, is now answered in the affirmative. Mr. David Forbes has brought from Peru a silver figurine, which represents a personage, probably an astronomer, holding to his eye a tube which is nothing else than a telescope. The figure is certainly of Peruvian origin, and dates from the period of the Incas.—*Translated for The Popular Science Monthly from the Revue Scientifique.*

In taking the recent census of India some difficulty was experienced, according to C. E. D. Black, in determining what should be regarded as a house. "The variety of structure was so great that a precise definition, such as satisfied census authorities in other parts of the world, became an impossibility in India. In the hill tracts one meets with collections of leaf-huts that are here to-day and gone to-morrow. Again, there is a portable arrangement of matting and bamboo that is slung on a donkey by the vagrant classes, though sometimes stationary on the outskirts of a village for months together. Then comes the more stable erection for the cultivator while engaged in watching his crops, and so on to the really permanent abode of the lower grades of village menials, with wattle and daub walls which last for years, and a roofing of thatch or palmyra leaves, renewed as necessary before each rainy season. In some parts of India a considerable space is walled in with a thick hedge of thorn or rattan, and the family expands in separate buildings as the sons marry, but all is considered to be a single 'house.' Pitched roofs, tiled or thatched, are usual in the moister tracts; flat-topped mud or brick buildings are almost universal in the dry plains of the Deccan and Upper India. Climate and the scarcity or plentifulness, as the case may be, are the main causes of the diversity of building; while social custom and the relative prevalence of the 'joint' or 'divided' family life among the Brahmanic classes often determine the interior construction and arrangement."

SKETCH OF ASAPH HALL.

IN spite of the few wonderful accidents that have led to great changes and advance in modern ideas, most of the real advances of the world have been the results of simple hard work and hard thinking by men of ability. As an example of the type of scientist who does not make astounding discoveries of doubtful value, but who surely and steadily advances the cause of science by faithful work, stands the astronomer ASAPH HALL.

He was born on October 15, 1829, in the little town of Goshen, in the northwestern part of Connecticut, where the Berkshire Hills come rolling over from Massachusetts. His grandfather, a Revolutionary officer, was one of the first settlers of the place, and was a wealthy man. But his father, through business failures, lost nearly all his property. In 1842 he died, leaving a wife and six children, of whom Asaph, then thirteen, was the oldest. Up to the time of his father's death Asaph's life was that of a well-to-do country boy. He had worked on the farm and he had gone to the village school. His father was far better educated than most of the men of the place, so that many good books fell into the boy's hands. Often his rainy days were spent in the garret, fighting the battles on the plains of Troy, or following Ulysses in his wanderings.

When his father died everything was changed. Almost all the property was mortgaged. In a family council it was decided to remain on one of the farms and try to pay off the mortgage. So Asaph and his mother set to work, and for three years toiled with might and main, carrying on the work of a large farm almost entirely by themselves. Asaph's mother was a tireless worker, and he helped her as best he could; but when the three years were past they found they had been able to pay the interest on the mortgage and nothing more. Sticking to the farm did not seem to pay, so Asaph decided to leave and go and learn the carpenter's trade. He persuaded his mother to move to a little place she owned free from debt, and he apprenticed himself to a local carpenter. He worked for three years for sixty dollars a year. At the end of that time he became a journeyman and worked for himself. He stayed in Litchfield County, helping to build houses and barns that are standing on the old farms to-day.

For six years he stuck to carpenter work, but all that time he was full of ambition. He saw that the men he worked with were a poorly educated set. They knew how to make a right angle by the three, four, five rule, but they had no idea at all of the reason for it. He was not satisfied to work in this blind rule-of-thumb

fashion—he wanted to know the reasons of things; so he kept picking up some knowledge of mathematics to help him understand his business. In the summer he was busy with carpenter work, but in the winter he generally went home. He did the chores on the farm in the early morning and at night, and went to school besides. As he learned more he decided to study and become an architect. He managed to spend one winter in Norfolk, Conn., under the instruction of the Principal of the Norfolk Academy. There he went through algebra and six books of geometry.

When he was twenty-five years old he had saved a little money from his carpenter work. Through the New York Tribune he saw that there was a college at McGrawville, N. Y., where a young man could earn his living and get an education at the same time. He decided to go to this college. So in the summer of 1854 he set out for Central College, as it was called. When he got there he found it was a very different place from what he had expected. It was open to both sexes and all colors, and was the gathering place of a queer set of cranks of all sorts. The teaching was poor, but still to the green country youth the experience was of immense value. His views were broadened and changed. He stayed at the college only a year and a half. In that time he went through algebra, geometry, and trigonometry, and studied some French and Latin. He soon proved himself to be by far the best mathematician in the college.

One of the students was a young woman named Angeline Stickney. She was a country girl of great sensibility and of fine mental qualities. She was working her way through college, and as a senior she helped in the teaching. Asaph Hall was one of her pupils in mathematics. Many were the problems he and his classmates contrived to puzzle their teacher, but they never were successful. When she was graduated Asaph Hall was engaged to her. He decided that he had stayed long enough at McGrawville. His money was about gone, and the college was poor. So in 1855 they set out together for Wisconsin. Angeline Stickney had a brother there, and she stayed at his house while Asaph tramped about the country in search of a school where they could teach. No school was open for them. They became tired of the flat, sickly country, and when spring came they decided to leave. On the 31st of March, 1856, they were married. Then they started for Ann Arbor. Asaph entered the sophomore and junior classes in Ann Arbor University, studying mathematics and astronomy under Prof. Brünnow. He found he could do good work in both these branches. His teacher encouraged him greatly. It was from him that he acquired his taste for astronomy. Prof. Brünnow was an excellent teacher, but he had trouble with his classes, and

his work was so changed and broken up that young Hall decided to leave after he had been there but half a year.

He went with his wife to Shalersville, Ohio, and took charge of the academy there. They conducted it successfully for a year, paying off all their debts and buying themselves new clothes, of which they were much in need. When the school was over they had no idea where to turn next. Hall wanted to go back to Ann Arbor and study again, but there was a great storm on the lakes at that time and his wife would not go. So they started East. He had had an offer from Prof. Bond, who was in charge of the Harvard College Observatory, of three dollars a week as assistant. Finally, he decided to accept it. He visited his old home in the summer, and in the fall of 1857 he took his wife to Cambridge and began his career as an astronomer.

Very few young married men of this day would like to start in a profession at the age of twenty-nine on a salary of three dollars a week. But young Hall expected he would be able to pick up outside work. He thought he could pursue his study in mathematics under Prof. Benjamin Peirce, then at Harvard. So he entered on his new life full of hope. He took a couple of rooms on Concord Avenue, near the observatory, and began housekeeping. He soon found he could not carry out all his plans. There was some quarrel between Prof. Peirce and Prof. Bond, and he could not study with the former without offending his employer. He had to give up that plan. His work at the observatory required long hours, but he managed to study a little by himself. He studied mathematics and German at the same time by translating a German mathematical work. His little income was all eaten up by simply the room rent. In order to live he had to do outside work. By computing, making almanacs, and observing moon culminations he doubled his salary and managed to scrape along. His wife worked by his side faithfully, encouraging him, helping him in his studies, and doing all the housework with her own hands. Hall soon became a rapid, accurate, and skillful computer. Soon his employers saw how valuable he was, and they gradually increased his pay, till at last he drew a salary of six hundred dollars a year.

He stayed in the Cambridge Observatory till the year 1862. At that time the war had been going on for a year. The officers at the Naval Observatory at Washington had gone off into the service of either the North or the South. Men were needed to fill their places. Hall was recommended to fill a position there. It was a good opening. He went to Washington, passed an examination, and was offered a place. In the fall of 1862 he went down to Washington to begin his work. The city was then in a ferment. Many of the officeholders were from the South. All sorts of jealousies

and meanness were rife in the departments of the Government. But he kept out of all disputes and settled down quietly to his work.

On January 2, 1863, he was appointed a Professor of Mathematics in the United States Navy. After that his career was assured, for his position was for life. Starting as a farmer boy, then turning carpenter, pursuing mathematics with the idea of becoming an architect, finally he had found the best field for his labor in astronomy. Up to this time his struggle was a hard one. He had never known what it was to have a moment of relaxation. It was toil from morning till night, and all that he did was for the personal benefit of others. After his appointment at Washington he was able to do work that counted for himself. So his public scientific career really began in 1862.

From 1862 to 1866 he worked on the nine-and-a-half-inch equatorial at the Naval Observatory under Mr. James Ferguson, making observations and reducing his work. One night, while he was working alone in the dome, the trap-door by which it was entered from below opened, and a tall, thin figure, crowned by a stovepipe hat, arose in the darkness. It turned out to be President Lincoln. He had come up from the White House with Secretary Stanton. He wanted to take a look at the heavens through the telescope. Prof. Hall showed him the various objects of interest, and finally turned the telescope on the half-full moon. The President looked at it a little while and went away. A few nights later the trap-door opened again, and the same figure appeared. He told Prof. Hall that after leaving the observatory he had looked at the moon, and it was wrong side up as he had seen it through the telescope. He was puzzled, and wanted to know the cause, so he had walked up from the White House alone. Prof. Hall explained to him how the lens of a telescope gives an inverted image, and President Lincoln went away satisfied.

After 1866 Prof. Hall worked as assistant on the prime vertical transit and the meridian circle. In 1867 he was put in charge of the meridian circle. From 1868 to 1875 he was in charge of the nine-and-a-half-inch equatorial, and from 1875 until his retirement on October 15, 1891, he was in charge of the twenty-six-inch equatorial. It can thus be seen that his practical experience as an observing astronomer has been long and varied.

During his stay at the observatory he was sent on several expeditions for the Government. In 1869 he was sent to Bering Strait on the ship Mohican to observe an eclipse of the sun. In those days one had to go to San Francisco by way of the Isthmus of Panama; all the instruments had to be sent the same way—so it was a big undertaking. In 1870–'71 he was sent to Sicily to observe another eclipse. In 1874 he went to Vladivostock, in Siberia,

to observe a transit of Venus. He visited China and Japan on the way. In 1878 he headed an expedition to Colorado to observe the eclipse of the sun, and in 1882 he took a party to Texas to observe another transit of Venus.

Although on these expeditions he did valuable service, it has been at Washington with the twenty-six-inch equatorial that he has done his most important work. He has made studies of many double stars, to determine their distances and motions. He has also given a great deal of time to the study of the planet Saturn. He made an especial investigation of the rings of this planet, and also discovered the motion of the line of apsides of Hyperion, one of Saturn's satellites. But by far the most important discovery he has made, the one that will connect his name with astronomy as long as the planets exist, was his discovery of the satellites of Mars. It had been thought by some old astronomer that perhaps Mars had satellites, but no one had been able to find them. In the fall of 1877 Mars was in a very favorable position to observe, and Prof. Hall turned his big telescope upon it. He searched night after night without finding anything new. He began to give up hope; but on the night of August 11th he discovered a little speck that turned out to be the outer satellite. Six days later he discovered the inner one. The discovery of these two little bodies (the smaller one being not more than fifteen miles in diameter) spread quickly among the observatories. The eager astronomers immediately began to find enough extra moons to supply another solar system. One observer insisted that there was one more moon at least, and Prof. Hall was blamed as stupid for not seeing it. But after a thorough investigation it was shown that Prof. Hall had discovered the two and the only two satellites of Mars.

This important discovery brought his name at once before the world at large, and was not slow in earning its reward. The Royal Astronomical Society presented him with a gold medal, and he was given the Lalande prize from Paris. Since that time his work has been recognized as it should. He has become a member of the most important scientific societies of this country, and an honorary member of the royal scientific societies of England and Russia and of the French Academy. The universities of the country have recognized his work, Yale and Harvard each giving him the degree of LL. D. The very last honor conferred upon him is the Arago medal, just awarded to him by the French Academy of Sciences.

Personally, Prof. Hall is a fine-looking man. He is tall and broad-shouldered. His forehead is high and deep. His eyes are clear and bright, in spite of years spent in gazing at the stars. He has always been strong and healthy. He is fond of the open

air, and has always taken exercise. So, in spite of his long years of hard work, he is now in perfect health. His success has not changed him in the least. He is always ready to help those who want to learn anything from him.

His writings have appeared mainly in astronomical magazines and in the Government reports of the work done in the Naval Observatory. They are all the results of practical astronomical work, and are mostly of a technical character. Consequently, they are of little interest to general readers. He has often been asked to write something for popular reading, but up to this time he has never consented to do so, thinking that there is already enough of such literature.

Prof. Hall is a self-made man. His life has not been an easy one. Every bit of his education, every one of his successes, has been gained by his own hard work. It was a steady uphill pull from the time he was thirteen years old until his appointment at Washington. In his younger days he saw many hard times. During a large share of that part of his life he had only one good suit of clothes in his possession. He and his wife were obliged to save every penny. From his early training and from such experience his habits were formed. Naturally they are of the simplest kind. He does not care for the luxuries of modern life. The comforts of a plain home are all he wants. He still lives almost as simply as when he was earning three dollars a week under Prof. Bond. He has never cared for society merely for its own sake, but he has been prominent in scientific circles. He is a quiet man who never pushes himself forward; yet, when he has anything to say, people are glad to listen to it.

In his ideas on politics, science, and religion he is liberal and yet conservative—that is to say, he has no objection to letting other people have their own thoughts and live their own lives. He can see no reason why science and real religion can not be reconciled. His views on religion and politics are sound. He does not care, however, to have anything to do with politics. He hates its corruption, meanness, and party quarreling. He has always been a little conservative in his scientific life. He has never been led into wild theories of no value. His work has been solid, earnest, and thorough, and will last forever. He is a widely read man, fond of study. He loves his work; so now, since his retirement in 1891, he continues his studies and investigations. He lives a quiet, simple life at his home in Washington, still advancing the cause of astronomy.

CORRESPONDENCE.

FLYING.

Editor Popular Science Monthly:

I WAS much gratified to see that Dr. Le Conte's very able and interesting article upon flying, in one of your recent numbers, fully recognized the fact that mere air in motion, commonly known as "wind," and popularly supposed to be in most cases moving at a uniform velocity, can not in the long run help a bird or a man to fly. In view of the large amount of foolishness published in the newspapers about rising in the air by the action of the wind, and the strong contrast that is drawn between wind and still air, it would seem probable that the writers in their rôle of would-be scientists base their doctrine upon the analogy of a rising kite. For the proper "squelching" of these notions their fallacy should be thoroughly exposed, and the real facts set forth as frequently as possible.

There is no question but that the apparent mysteries of rising, soaring, etc., without propulsive action, are due, as has been stated, to variations in air velocity rather than to that velocity itself. These variations can, of course, act only in conjunction with inertia. The bird or other flying machine, drifting with the air at its average speed, takes advantage of the inherent tendency of his mass to maintain its present rate of motion (whether positive or negative or *nil* in relation to the earth's surface) for a short time after the air velocity has changed, thereby lifting him up by some local body of air with, say, a suddenly increased velocity, acting as a wedge beneath the front of his wings (or other aëroplane) while he temporarily stays still, or nearly so, in reference to the general body of the air. Should there be a local decrease of velocity the conditions would be equivalent to a "breeze astern," and the rear edge of his wings would have to be elevated at an angle with the plane of the wind's motion—that is, if he wished to continue rising. All this is obviously upon the same principle as a block lifted by a wedge slid under it, which can be pushed up so long as it moves forward against the wedge or remains stationary or moves backward with the wedge, but at a slower rate of speed.

If the bird was so fortunate as to be held with the earth against the motion of the wind by a guy-line, after the manner of a kite, or if the block was held from a retrograding motion by a line in front or by a strut behind it, the matter would of course be perfectly simple; but it must be strongly impressed upon the popular mind that there is in the case of flying creatures no such holding action except that due to inertia, the which can last but a short time. We must therefore assume frequent changes of air velocity to account for the soaring which we so frequently see materialized as an actual fact. Going back to the analogy of the wedge, a very simple experiment will show that the block can be raised much higher by striking the wedge a quick blow, thereby taking a very full advantage of the inertia of the block, than it can when the wedge is pushed in slowly. If too slowly, its action will of course be *nil*, and the block will move back with it instead of rising.

Now it is obvious that we all of us know little enough about the principles of flying, but the first fact to be thoroughly impressed upon the mind of any would-be student of this subject is that wind, regarded usually as air in motion, must be considered as air at rest, and the earth as a moving body sliding along underneath it. Of course, this motion of the earth will make a difference to our future flying machines in regard to the time required to get from one place to another, according to its direction; but as far as the operations of propelling, soaring, etc., are concerned, the idea of wind must be left entirely out of the question except so far as we can learn about and deal with its frequent and rapid variations in velocity. It is probable, however, that these are too uncertain to depend upon, and our mechanical efforts must be directed toward getting any desired motion we wish in a medium of air at rest. The item of wind has therefore, as before stated, nothing whatever to do with the subject except as regards certain difficulties in stopping and starting from the surface of the earth and the time, with a given power, required to traverse given distances thereupon. OBERLIN SMITH.

BRIDGETON, N. J., *July*, 1894.

A REMONSTRANCE.

Editor Popular Science Monthly:

DEAR SIR: In your August number it was apparently claimed that the specialty of women, as women, is their power of intuition. But what is intuition? Dictionaries and general usage seem to make the word synonymous with instinct.

Now it is not so long since it was generally insisted that animals could never reason, but acted by instinct only; and in spite of much talk about "God-given instinct," the talkers actually, and not always secretly, considered their theory as a firm ground for despising animals as unintelligent.

At present, thinkers seem to acknowledge that animals can and do reason; and scientific men cease giving instinct as a cause for the conduct of animals. Will these thinkers now put women on a lower level than animals, or do they limit the word "reasoning" to slow action of the mind, and refuse it as a term for quick mental action? That were strange!

As a woman, I have seen much of women. I have yet to find one with real powers of intuition. I will not call her impossible. Instead, I encounter foolish women, who act from prejudice or impatience; wise women, who base their actions on great quantities of observations continually renewed and compared, as constant and careful as those of an accomplished detective; and a variety of women between these types. But—so absurd is the human being under the sway of conventionality—some of the wise actually made themselves believe that they acted and judged by intuition, because they had been told that women did so.

Furthermore, kindness may not require much reasoning power in the kind person, nor may mere abstention from vice in the abstainer; but I have always found that active goodness—and what other sort deserves the name of good?—needed reason to be brought into play as much as feeling.

Elizabeth Winthrop Johnson.

EDITOR'S TABLE.

ANOTHER RAID ON THE DOCTRINE OF EVOLUTION.

A FEW months ago we referred to the objections which had been made to the teaching of modern scientific views in the University of California; but fortunately we were able to state that much public sympathy had been extended to the incriminated professors, and that they were able to hold their positions without any curtailment of the liberty they claimed of imparting the best scientific instruction in their power without regard to preconceived notions or theories. Even as we wrote there was similar trouble brewing, though we were not aware of it, in the University of Texas. The results in the latter case, if we are rightly informed, have been far less satisfactory than in the former. The Texan conscience, it seems, is a very tender one; and when it became mooted that Dr. Edwards, the Adjunct Professor of Biology, was teaching on evolutionary lines, and that the ingenuous youths who attended his classes were in danger of imbibing such ideas as that the world may not really have been made in six days, and that the countless species of plant and animal life now existing or that have existed in the past may not have been called separately into being by so many distinct acts of creation, there was much heart-searching on the ranches, and an enlightened public opinion determined that something must be done at once. They can stand a good many things down in the Lone Star State, but heterodoxy and horse-stealing are two things they will not stand if they can help it. As the Austin Daily Statesman elegantly expressed it: "The mind of the common people of Texas is wonderfully set and united on the verity of the old Bible as she stands in the King James version. The least hint that anything is being taught in any school that will unsettle the faith of their children in the good old Bible doctrine of the creation of matter, the origin of life, and the descent of the race from Adam and Eve, without going any further back in the pedigree, will raise the 'Old Henry' and wake the reptile that sleeps on the log in the sun with pious fathers and mothers all over the State. The origin of man, as set forth in the Bible in a pretty clear fashion, is made in the image of God with a natural body and a reasonable soul. It was a creative act of almighty power immediately performed with no intermediate ancestry."

The slight literary defects which the

above extract—given, of course, textually—may reveal do not impair the lucidity with which it sets forth the views of "the common people of Texas." Whether Dr. Edwards had or had not heard of "the reptile that sleeps on the log with pious fathers and mothers all over the State" we are not informed. All we know is that, intentionally or unintentionally, he roused it from its slumbers, and that it was not long in stinging into action the regents of the university. A three-years' engagement had been entered into with the professor, only a short part of which had expired; but under the attacks of "the reptile" the regents made short work of their contract, and sent Dr. Edwards to teach his evolutionary doctrines elsewhere. It is rumored, indeed, that another reptile was roused into life at the same time as the orthodox one—namely, the reptile of local jealousy. The professor was not a Texan, and this, added to the fact that he was an avowed evolutionist, caused him to receive a very short shrift. One or two other professors, according to the journal above quoted, took the hint and, with a wisdom somewhat resembling that of Colonel Crockett's coon, "came down"—that is to say, resigned—so that at this date the university may claim to be tolerably free from the leaven of evolutionary theories.

Perhaps it is best. Texas is a remote State, and many things there are in a very primitive condition. It is a land where one man's opinion is as good as another's, and where any little defects in a gentleman's logic can be handily repaired with a six-shooter. According to the Daily Statesman, which ought to know whereof it affirms, "the common people" do not look upon schools and universities as places where some things may be taught of which they are themselves ignorant, but as places the instruction in which they are entirely competent and entitled, in the fullness of their knowledge, to direct. *They* know how the different forms of organic life came into existence, and no professor—particularly one from another State—is going to steal into their institutions of learning (save the mark!) and teach anything on this subject contrary to what they hold. Well, we think there is something in Mr. Spencer's works which fits this case. He says, in the preface to the Data of Ethics, that evil results may flow if people take up evolutionary views before they are really fitted for self-guidance. For some communities and individuals of a backward type the strong, not to say, coarse sanctions of a primitive theology are better and safer than the broader but less potent motives which the scientific view of the world and of human life affords. We are therefore by no means disposed to hold that the Texans do not know what is good for them. With a little change of dialect they might say with Tennyson's Northern Farmer:

> "Doctors, they knaws nowt, for a says what's nawways true;
> Naw sort o' koind o' use to saäy the things that a do."

And just as the northern farmer had had his pint of ale every night for forty years, and insisted on having it still in spite of doctors, so "pious fathers and mothers all over the State" have been accustomed to the biblical version of the origin of species, and will have it in spite of all new knowledge and all improved theories. There is no great harm in this so long as the thing is thoroughly understood. We sympathize with Prof. Edwards in the disappointment which the untimely termination of his engagement doubtless caused him; but if any other trained biologist accepts a situation in the University of Texas it will be his own fault. The simple truth is that biological science can not as yet be taught in that State—at least not under the auspices of the State. Well, biological science can wait until the quarantine against it is raised, which, of course, it will be some day. The suf-

ferer meanwhile is the State, which condemns its young men either to listen to antiquated and utterly inadequate discussions of biological questions in the State university or else to go abroad for the knowledge which is denied at home.

THE AMERICAN ASSOCIATION IN BROOKLYN.

The American Association had a very pleasant and profitable meeting in Brooklyn. That city has a peculiar character among American towns of great size in being a city of homes rather than of business, and is the residence of a large number of liberal-minded, public-spirited men, and of women warmly interested in everything tending to promote advance in knowledge and the means of right living. The scientific students of the country could not fail to find themselves at once at home among such people. This feature of the social and intellectual life of the place was well presented by Dr. Backus in his address of welcome to the association, when, referring to the fact that the citizens had failed to secure the great university of which they had dreamed, he intimated that they had a more than abundant compensation in the great private high schools of world-wide reputation, generously supported by the public without governmental or municipal aid, and appropriating their annual surplus revenues to the strengthening of their faculties and equipments; besides supporting the largest free high schools for young men and for young women in the world, and possessing as superstructures on the private foundations of generous benefactors an institution furnishing "the most practical, the most extensive, and the most advanced system of industrial instruction to be found in our country," and another which maintained twenty-six departments of original scientific research. Dr. Brinton replied in behalf of the association, that it recognized and appreciated the advantages of a reunion in a city "whose streets are lined with edifices erected by the munificence of a few for the benefit of the many, and which in so many features testifies to the broad liberality and enlightened intelligence of its foremost citizens."

Dr. Brinton in his address described the association as a body cultivating a science the spirit of which is to seek as its goal truth, "the one test of which is that it will bear clear and untrammeled investigation"; which admits and appeals to no other evidence than "that which it is in the power of every one to judge, and which is absolutely open to the world, having about it no such thing as "an inner secret, a mysterious gnosis"; a science at once modest in its own claims and liberal to the claims of others, and "noble, inspiring, consolatory" in its mission, "lifting the mind above the gross contacts of life, presenting aims which are at once practical, humanitarian, and spiritually elevating." Dr. Harkness, the retiring president, chose as his subject the magnitude of the Solar System and the elements which enter into the determination of it. His address, while it contained much matter of great interest, was largely technical, dealing considerably with mathematical discussion, and is hardly susceptible of being presented in popular form.

The vice-presidential addresses, likewise, tended to be technical. Dr. Franz Boaz discussed the relation of Race Faculties to the Advancement of Civilization, maintaining that too much emphasis has been laid upon them at the expense of the environment, which is also a factor of very great importance. Vice-President G. C. Comstock addressed Section A upon Binary Stars. Prof. Mansfield Merriam, in the Section of Mechanical Science and Engineering, considered the Resistance of Materials under Impact. In his address upon a Stable Monetary Standard, Vice-President Farquhar, in the Section of Eco-

nomic Science and Statistics, favored the abandonment of attempts to establish a legal tender by legislation, and the leaving of the question to settle itself. The Battle with Fire was the subject of an address by Vice-President Norton's before the Chemical Section, which embodied an account of the contributions which chemistry has made to the art of extinguishing fires and of preventing them, and contained many practical hints. In the other sections, Vice-President Samuel Calvin described the Niobrara stage of the Upper Cretaceous; Prof. W. A. Rogers spoke of obscure heat as an agent in producing expansion and contraction of metals; and Prof. L. M. Underwood discussed the evolution of the *Hepaticæ*. While a large proportion of the papers read in the sections were technical and limited in their bearing, a considerable number were also of great general interest.

The meetings of the affiliated societies attracted nearly as much interest as those of the association itself, and papers were read in them which were, to say the least, equal in merit and importance to the average of those which were read in the association. We regard these societies as still in the experimental stage; and it appears to be yet to be determined whether their influence as a whole will be beneficial or the contrary to the general body.

Amendments to the Constitution were proposed for consideration next year, to admit libraries and societies to representation in the association through one of their officers, and to add a Section of Sociology.

The members of the association enjoyed the full measure of the social exchanges and festivities which attend the body wherever it goes. Excursions were made to many points of scientific interest. There were some features to be criticised about the meeting. The relatively small attendance at the very interesting lectures of M. Du Chaillu and Prof. Cope was hardly creditable to the citizens of Brooklyn, in whose honor they were especially given. A deficiency of provisions for the comfort of the attendants of the meetings, particularly in the matter of directions for finding the way, was complained of; and imperfections in the arrangements of some of the excursions revealed a want of adequate central control.

LITERARY NOTICES.

An Introduction to the Philosophy of Herbert Spencer. By William Henry Hudson. New York: D. Appleton & Co. Pp. 234.

This book is largely an outgrowth of lectures delivered from time to time on Mr. Spencer's Philosophy. The book itself was undertaken to meet what seemed a healthy popular demand. Mr. Hudson had observed with some surprise the widespread diffusion of interest in the subject of evolution. His lectures were heard by attentive and appreciative audiences, and cultivated men and women, especially the younger ones, expressed the desire to know more of the new thought and of its bearing upon the practical problems and issues of the day. He could not refer all inquirers to Mr. Spencer's works; for, clear and forcible as is the presentation in them all, they are too voluminous and the style of their writing is too condensed for any but persons having abundant time and strong powers of concentration to master them in bulk. Therefore the author has undertaken to furnish this introduction as a sort of guide or handbook to the complete works, by the aid of which readers may gain a kind of bird's-eye view of the system as a whole, or, if they are disposed and able to examine it more in detail, may be assisted in their course through its different regions. In this he has succeeded admirably, and his book is marked throughout by a clearness of statement which will enable any one of average intelligence to follow the author through even the most abstruse parts of the discussion. The examination of Mr. Spencer's work is preceded by a biographical sketch of the philosopher —the most satisfactory and probably the only full one that has been presented. In it

all the incidents which had a part in shaping Mr. Spencer's career, and in directing his thoughts to the course they took, are plainly set down, with the several stages in the development of his scheme, and the order in which its different parts were conceived or brought forth. Two chapters are then devoted to Mr. Spencer's earlier work—to the preparation for the Synthetic Philosophy—and to the Synthetic Philosophy itself. Here pains are taken to place in its proper light Mr. Spencer's connection with the modern doctrine of evolution, and to show him to be the originator of it—antedating Darwin and all others many years in the conception and first publishing of it, as we have often shown in the Monthly. These chapters deal to a considerable extent with the abstract and metaphysical aspects of Mr. Spencer's work, but only as a necessary introduction to what is to follow; for it is not the author's purpose to consider the philosophy as an abstract conception or a piece of metaphysical rationalistics, but rather to demonstrate it as a scheme of life and of reigning natural law; and he does this with a success that is nothing less than remarkable. This is, in fact, one of the most important characteristics of the volume. No pains are spared to make prominent the practical element in Mr. Spencer's philosophy, to exhibit the bearing of his writings on current problems, and to show how the system fits to all the various relations of the world's growth and the exigencies and duties of life. Of all men's, Spencer's thought has been most potent in shaping and directing the intellectual movement of the latter half of the century; and it has been so by reason of the immediate bearing of his teachings not only on the everyday questions that occupy men's minds, but also on those larger problems which are pressing on all sides for solution. Every man of whatever calling or aim who reads them attentively will find in them what will aid him in the pursuit of his profession or his object. This bearing appears throughout in Mr. Hudson's book, and especially in the chapters on the Spencerian sociology and on the ethical system and the religious aspect, not because of efforts to exhibit it—for such efforts are wholly absent—but logically and naturally, as a part of the thing itself. Mr. Hudson is at some pains to explain the exact meaning of Mr. Spencer's "Unknowable," and to correct the impressions that have been industriously cultivated by prejudiced antagonists that he is a materialist or an agnostic in any atheistic sense; a pains which is supererogatory as to persons who will carefully read what Mr. Spencer says, but may be necessary as to those who come to his writings burdened with the endless reiteration of misrepresentations. Those who read this little book can hardly fail to be impressed with the great importance and wholesome character of Mr. Spencer's writings, and to desire to know more of them.

Folk Tales of Angola. Fifty Tales, with Ki-Mbundu Text, Literal English Translation, Introduction, and Notes. Collected and edited by Heli Chatelain. Boston and New York: Houghton, Mifflin & Co., for the American Folklore Society. Pp. 315, with Map. Price, $3.

The author visited Africa as pioneer and linguist of Bishop Taylor's self-supporting missions. In his studies of the native language he found that all the dialects spoken at Loanda and Angola and those of the adjoining districts formed one language, and that that language—the Ki-Mbundu—was worthy of the founding of a literature. He published some elementary books in it, and by the aid of an intelligent native was able to take down a large number of folk tales, riddles, songs, and proverbs, of which the present volume is only a first installment of what he intends to publish. After comparing the whole material, the author has found that many of the myths, favorite types or characters, and peculiar incidents which have been called universal, can also be traced through Africa from sea to sea, and that African folklore is not a tree by itself, but a branch of one universal tree. Though Portuguese and Arabian influence is evident in many of the stories, still the bulk of the tales is purely native. African folklore is especially rich in animal stories or fables. The folklore of the Bantu appears to be remarkably homogeneous and compact, while the Nigritic folklore, after the exotic elements connected with Islam are eliminated from it, is found to be virtually the same. The mythologies and superstitions of the various tribes are easily reducible to one

common type, and this is strikingly similar to the popular conceptions of the Aryans and other great races when not identical with them. The stories are classified as traditional stories regarded as fictitious; stories reported as true, or anecdotes; historical narratives; stories of moral philosophy, or proverbs; poetry and music, and riddles. The myths and tales of the negroes in America are all derived from African prototypes, and through the American negro have exercised a deep and wide influence on the folklore of the Indians, and even of the American white race. This fact gives strong incentives to the study of the subject by Americans. Besides the stories, an analysis is given of their general features, a bibliography, directions for the pronunciation of Ki-Mbundu, a description of the country and people, and copious illustrative notes.

Report of the Commissioner of Education for the Year 1890–'91. Washington: Government Printing Office. Two volumes. Pp. 1549.

The whole number of pupils in schools of all grades, public and private, is given at 14,669,069, constituting 23·09 per cent, or not quite one fourth, of all the population. Besides these are to be counted pupils in evening schools, art, industrial, and business schools, schools for defective classes and for Indians, in all about 300,000 pupils, which would swell the whole number to nearly 15,000,000. The commissioner remarks upon a correspondence between the waves of industrial prosperity and depression that pass over the country and the relative attendance upon the private and the public schools. The whole number of teachers in schools of both kinds is nearly 425,000. The entire expenditure during the year for public schools was $146,800,163, or $17.67 for each pupil attending 135·7 days, and $2.31 per capita of the whole population. Of the income for schools nearly seventy per cent comes from local taxes and nineteen per cent from State taxes. Besides these and other statistics of the schools in the United States, the first volume of the report gives papers on Secondary Education in New Zealand; Education in France; a review of the Educational Systems of England and Scotland and their Operations for 1890–'91; the Educational System of Ireland; Industrial and Technical Education in Central Europe, Education in Russia, Japan, Italy, Corea, and Hawaii; Legal Education in the United States and in Canada, Australia, Spanish America, Japan, and China; Colleges of Agriculture and the Mechanic Arts. The second volume gives a "Name Register" of State and City Educational Officers; statistics of city, secondary, higher, and professional schools; papers on Education in Alaska, the Education of the Colored Race, Class Intervals in City Public Schools, Educational Statistics, discussions of current educational questions, a report on the physical and mental condition of 50,000 London school children, and Facilities in Experimental Psychology in the Colleges of the United States. These articles are followed by statistical tables.

Science and Hebrew Tradition. By Thomas H. Huxley. Collected Essays, Vol. IV. New York: D. Appleton & Co. Pp. 372. Price, $1.25.

The essays contained in this volume are concerned mainly with the question whether the Old Testament is wholly true or partly legendary. The first three, however, have no direct connection with those that follow. They deal with the discoveries and inductions of paleontology, and can be said to bear upon the above question only by furnishing samples of the scientific method of research. They include Prof. Huxley's lectures on evolution delivered in New York in 1876, and his lecture on the Method of Zadig. The fourth essay of the volume, entitled The Interpreters of Genesis and the Interpreters of Nature, was written for a controversy with Mr. Gladstone upon the correctness of the account of creation in the book of Genesis. The one following—Mr. Gladstone and Genesis—is a continuation of the same theme. In both of them Prof. Huxley denies that the order in which the several kinds of living creatures are said to have been created is the same as that revealed in the records of paleontology. In the next two essays he gives the facts which conflict with the story of the Noachian Deluge. The last in the volume is A Study of the Evolution of Theology, the data for which are drawn from the practices of the ancient Israelites and of certain Polynesian tribes.

Believing that all claims to infallibility

are pernicious, Prof. Huxley states in his preface that these essays are intended to combat certain of such claims. "Unless I greatly err," he says, "the arguments adduced go a long way to prove that the accounts of the Creation and the Deluge in the Hebrew Scriptures are mere legends; and, further, that the evidence for the existence and activity of a demonic world, implicitly and explicitly inculcated throughout the Christian Scriptures, and universally held by the primitive churches, is totally inadequate to justify the expression of belief in it. This much on the negative side of the discussion. On the positive side, the essay on the Evolution of Theology, as I imagine, shows cause for the conclusion that the Israelitic religion, in the earliest phase of which anything is really known, is neither more nor less rational, neither better nor worse ethically, than the religions of other nations in a similar state of civilization; that in the natural course of its evolution it reached, in the prophetic age, an elevation and an ethical purity which have never been surpassed, and that, since the new birth of the prophetic spirit, in the first century of our era, the course of Christian dogmatic development, along its main lines, has been essentially retrogressive."

It will thus be seen that Prof. Huxley aims to be not a destroyer but a purifier of religion.

Elementary Lessons in Steam Machinery and the Marine Steam Engine. With a Short Description of the Construction of a Battle Ship. By Staff-Engineer J. Langmaid and Engineer H. Gainsford. New York: Macmillan & Co. Pp. 267. Price, $2.

These lessons, prepared for the naval cadets in one of the vessels of her Majesty's fleet, are intended to represent a systematic course of simple instruction preparatory to a more thorough study of the whole subject. In the earlier lessons instruction is given in the elements of construction and mechanism, and in those mechanical details which students are usually expected to learn by workshop experience. The conclusions given are wholly such as have been arrived at by experience, and the various details of marine engines are illustrated by the simplest examples. The lessons on Construction include the principles of measurements, the uses and qualities of the metals used, and instructions concerning riveted joints, screw threads and fastenings, transmission of power by shafts, etc.; conversion of motion, toothed gearing, friction, stuffing boxes and packing, joints of pipes, etc.; valves and cocks, and pumps. The lessons on the marine steam engine relate to boilers and boiler mountings and engines, with the details similarly separately considered.

Aëro-Therapeutics; or, The Treatment of Lung Diseases by Climate. With an Address on the High Altitudes of Colorado. By Charles Theodore Williams. New York: Macmillan & Co. Pp. 187. Price, $2.

This work, by the Senior Physician in the Hospital for Consumption and Diseases of the Chest, Brompton, and late President of the Royal Meteorological Society, consists of the Lumleian Lectures for 1893, delivered before the College of Physicians. In his lectures the author has attempted to sketch a scientific system of aëro-therapeutics, based on the combination of modern meteorology with clinical experiment, in which each element of climate is duly considered in its bearing on health and disease. The lectures severally relate to the factors and elements of climate, temperature and moisture, and barometric pressure in its relation to health and disease. In the summary of results of different climates compared, at the close of the regular lectures, a marked preponderance is found in favor of high altitudes as against the English home stations, the Riviera, and sea voyages. The address on the high altitudes of Colorado embodies a clear account of the character and climate of the country, and a strong appreciation of its value to health.

The Conquest of Death. By Abbot Kinney. New York. Pp. 259.

The author is struck with the deficiency of children in American families and the apparent prevalence of the habit of limiting the number of children, and forebodes disaster from it. "For some twenty years," he says, "fact after fact has forced upon me the reluctantly received opinion that the present vital movement in our population can only eventuate in the elimination of the old American stock through nonreproduction. It is impossible to disguise the fact that in many

places the population is maintained or increased by immigration, or by the children of recent immigrants. The fidelity of these to the duties of marriage is largely due not to the reason but to useful superstition. Intellectual inquiry invites infidelity. Skepticism has no soul, nor has it breeding power. Man must have a belief to be in earnest. The skeptics disappear, the superstitious survive, but progress can not live without intellectual activity. This is incompatible with the infallibility demanded for the integrity of superstition. So long as there is progress there must be intellectual independence. Here, then, is the dilemma—skepticism and sterility, or superstition and stagnation; progress to extermination, or perpetuation of life without improvement. This problem, and others kindred to it, are those for which I have sought a solution." Finally, the main motive of the work is declared to be the necessity of reproduction in man to enter any demonstrable future. The subjects of Sex, Marriage, Husband Choice, Wife Choice, The Child, Hints to the Husband, A Word to the Wife, and Religion, are discussed.

The Theory of Heat. By Thomas Preston. New York: Macmillan & Co. Pp. 719.

The author's object in preparing this volume has been to treat the science of heat in a comprehensive manner, so as to produce a tolerably complete account of the whole subject in its experimental as well as in its theoretical aspect. He has consequently enjoyed a freedom in his choice of subject-matter and mode of exposition which would not have been possible in a work designed to meet the requirements of some particular class of persons preparing for examinations or engaged in practical pursuits. The nobler aspect of science as an instrument of education and culture is kept in mind throughout, and the principle is enforced that an acquaintance with a number of facts does not constitute a scientific education, and there is no royal road to learning other than that by which it is pursued for its own sake. The most fruitful method of exposition, it is observed, is not necessarily that by which a given number of facts may be recorded in the shortest space, but rather that by which they may be most easily assimilated by the mind and most comprehensively grasped in their general bearings and mutual relations; and this is the method which is most calculated to advance knowledge and raise the intellectual character of the individual. The historical method of treatment is preferred, as admitting the most constant comparison of theory with the results of experiment and the closest scrutiny at every step of the development. With this is combined a due amount of detail in description and explanation to secure instruction and such suggestion and criticism as may excite intellectual life and independent thought on the part of the student. The classical experiments are given in detail, and in addition such other investigations are noticed as will give the student a general idea of the work that has been done in each department up to the present time. In the introductory chapter, or "preliminary sketch," some remarks are given on the general effects of heat and on the meaning of the terms used in the subject, the theories of heat are reviewed, and the subjects of matter and energy and the theories concerning them are discussed. In the subsequent chapters, thermometry, dilatation, calorimetry, change of state, radiation and absorption, conduction, and thermodynamics are considered. Such subjects as the steam engine and the theory of solutions are omitted, as having obtained separate treatment in special works. The kinetic theory of gases has been entered into so far as to meet the immediate requirements of the subject in hand; and the suggestion is made that it, with some other subjects usually dealt with in treatises on heat, are deserving of treatment in a separate volume.

Science and Christian Tradition. By Thomas H. Huxley. Collected Essays, Vol. V. New York: D. Appleton & Co. Pp. 419. Price, $1.25.

This volume contains ten of Prof. Huxley's vigorous magazine articles, first published in the years 1887 to 1891, to which is prefixed the Prologue to his volume entitled Controverted Questions. Among these essays are his series of three on agnosticism, and his two on the Gadarene swine miracle in controversy with Mr. Gladstone, while the others deal mainly with other miracles of the New Testament. In the essay on The Value of Witness to the Miraculous, Prof. Huxley scrutinizes certain mediæval miracles

recorded by Eginhard, a writer of the time of Charlemagne; and in the one on Possibilities and Impossibilities he examines the two accounts of the feeding of multitudes with a few loaves and fishes. The somewhat extended preface to this volume includes an argument against the demonology, or belief in various kinds of evil spirits, which has been made a part of Christian theology. It includes also a statement of the "Synoptic Problem"—i. e., the question as to how, when, and by whom the gospels which bear the names respectively of Matthew, Mark, Luke, and John were written. In looking back over his various discussions of theological doctrines, Prof. Huxley declines to admit the charge that he has "gone out of his way" to attack the Bible; "and I as steadfastly deny," he continues, "that 'hatred of Christianity' is a feeling with which I have any acquaintance. There are very few things which I find it permissible to hate; and though it may be that some of the organizations which arrogate to themselves the Christian name have richly earned a place in the category of hateful things, that ought to have nothing to do with one's estimation of the religion which they have perverted and disfigured out of all likeness to the original."

The subject of *Helical Gears* is not a very familiar one, but it appears to be of such growing importance as to warrant a special treatise upon it. In preparing his volume, *A Foreman Pattern-maker* has treated with much detail of illustration the true and only workable methods of development of spur and bevel wheels, and has entered fully into the proper methods of construction of the pattern parts. He has also explained the methods of molding these gears by machine. He has aimed to make his book practical and adapted to the shop and the technical school. (Published by Macmillan & Co., at the price of $1.)

George M. Dawson, in his *Geological Notes on some of the Coasts and Islands of Bering Sea and Vicinity*, notices as one of the most remarkable features of the region the absence of any traces of a general glaciation. Respecting the latest changes in elevation of the land, evidences of a recent slight general uplift are mentioned as visible in several widely separated places. Mr. Dawson also sends us *Notes on the Geology of Middleton Island, Alaska*. Both these papers are published in the Bulletin of the Geological Society of America.

Hugh M. Smith, M. D., reprints from the Bulletin of the United States Fish Commission *Economic and Natural History Notes on Fishes of the Northern Coast of New Jersey*, and a paper on *The Fyke Nets and Fyke-net Fisheries of the United States*, with notes on the fyke nets of other countries. In the former paper the subject of Ocean Pound Fishing is dealt with.

The function of dynamics in evolution is discussed by *John A. Ryder* in a lecture delivered by him in August, 1893, at Woods Hole Biological Laboratory on *Dynamical Evolution*. The author concludes that observers have hitherto allowed purely morphological considerations to becloud their vision; and that when each of the five sciences—physics, chemistry, physiology, morphology, and psychology—"shall have been given its due weight and place in the conduct of the study of life-forms, we shall begin to know what the latter really means, but not till then." (Published by Ginn & Co., Boston.)

J. W. Spencer, State Geologist, publishes as a part of his work *The Palæozoic Group—Ten Counties of Northwestern Georgia* (Polk, Floyd, Barton, Gordon, Murray, Whitfield, Catoosa, Chattooga, Walker, and Dade Counties), embracing the Geological and Physical Characteristics, Economic Geology, and Soils. A chapter on Good Roads is incorporated in the report, and the whole is illustrated by a geological map.

A part, including numbers six to twelve of Vol. VII of the *Annals of the New York Academy of Sciences*, contains Coleopteriological Notices, by T. L. Casey; A Revision of the American Cielidæ, by C. H. Eigenmann and W. L. Bray; Notes on some South American Fishes, by C. H. Eigenmann; and The Granite at Mounts Adam and Eve, Warwick, Orange County, N. Y., and some of its Contact Phenomena, by J. F. Kemp and Arthur Hollick.

In a paper on *The Widening Use of Compressed Air*, applications of this force are mentioned by *W. P. Pressinger* in the work of the pneumatic dynamite gun; in pneumatic block signaling; to raising water

from deep wells; to spraying oil into petroleum furnaces: as a stirrer, cooler, etc., in various chemical manufacturing processes; in pneumatic elevators, cranes, and hoisting machinery; in pneumatic transmission tubes; in refrigerating and ventilating; in the propulsion of cars; in the purification of water supplies; and in various other operations in which compressed air appears as a power, "ever ready to do our bidding, summoned or dismissed by the simple turning of a valve."

In his *Contributions to the Morphology of Cladoselache* (Cladodus)—a fossil shark—considerable attention is given by *Bashford Dean*, of Columbia College, to the development of the fins and of the heterocercal structure. (Published by Ginn & Co., Boston.)

The Eighth Annual Report of the Commissioner of Labor—for 1892—relates to industrial education, and comprises the results of inquiries on the subject made at home and abroad. The schedule of questions under which the information was obtained covered a wide scope, and included such topics as the age of the student workman, the occupations he had followed, the nature of his previous training, his proficiency in the use of tools and material, whether he attained an average degree of skill and efficiency in the use of tools quicker than those who had not had manual or trade training, whether he had acquired greater economy in the use of materials, whether he was more proficient in the things that indicate mental cultivation, whether he promised to become a more intelligent workman, whether he received better compensation than persons not coming from the technical schools, and many other points. In its original work the department has received the aid of several men—experts and specialists—not generally employed by it, to whom acknowledgment is made by name. *Carroll D. Wright*, Commissioner.

Number 4 of Volume V of *Studies from the Biological Laboratory of Johns Hopkins University* contains four papers. The first and most extended of these is an account of An Undescribed Acraniate: Asymmetron Lucayanum, by E. A. Andrews. The creature is a small lancelet found in the Bahamas. Maynard M. Metcalf furnishes for this number Contributions to the Embryology of Chiton, a first paper, and Dr. John P. Lotsy contributes the beginning of an opus on The Formation of the So-called Cypress Knees. The fourth paper is a brief statement on The Origin and Development of the Stichidia and Tetrasporangia in Dasya Elegans, by B. W. Barton. The several papers are accompanied by plates and figures.

The sixth special report of the United States Commissioner of Labor, Hon. *Carroll D. Wright*, is an account of *The Phosphate Industry of the United States.* This industry is carried on in South Carolina and in Florida, having become established first in South Carolina, and extends somewhat into adjoining States. The report describes these two chief fields separately, giving the geology of each, an account of the methods and machinery employed in mining each of the several kinds of phosphate rock, statements of analyses, and general observations. There are also detailed statistics as to rates of wages, prices of machinery, royalties to the State in South Carolina, freight charges, and other elements in the cost of production, the quantities consumed in a term of years, etc. The report is illustrated with several photographic views and diagrams, and two folded maps.

An article by *Arthur Hollick*, reprinted from the Bulletin of the Torrey Botanical Club, on *Additions to the Palæobotany of the Cretaceous Formation on Long Island*, describes forty-six species of plants (leaves) found in this formation, additional to the ten species described in a previous paper. Of these, nine species are new. An accompanying paper—*Some Further Notes on the Geology of the North Shore of Long Island*—embodies a discussion of the "preglacial" or "yellow gravel" of the district named, and its probable relation to the cretaceous of New Jersey.

At an educational conference on geography held in Chicago in December, 1892, *W. M. Davis*, *C. F. King*, and *G. L. Coltie* were appointed to prepare a selected list of topographical maps published by the various Government bureaus, making special mention of such sheets as might best illustrate the physical features of our country. It was desired that the list should be distributed among school superintendents and teachers as an aid in securing for the high schools the specified maps, together with the map of

the district in which the school is situated, to be introduced in the teaching of geology. The list thus contemplated is published, with brief commentaries pointing out the significance of the several maps, by Henry Holt & Co., in the pamphlet, *The Use of Government Maps in Schools*. It describes sixty-eight maps. (Price, 30 cents.)

Mathematical students of the higher branches will understand and appreciate *Alexander Macfarlane's* setting forth of *The Principles of Elliptic and Hyperbolic Analysis*. In it the fundamental theorem of trigonometry is investigated for the sphere, the ellipsoid of revolution, and the general ellipsoid; then for the equilateral hyperboloid of two sheets, the equilateral hyperboloid of one sheet, and the general hyperboloid. Subsequently, the principles arrived at are applied to find the complete form of other theorems in spherical trigonometry, and to deduce the generalized theorems for the ellipsoid and the hyperboloid. At the end, the analogues of the rotation theorem are deduced. (Author's address, Austin, Texas.)

A paper by *J. F. Kemp* in the Contributions from the Geological Department of Columbia College, on *Gabbros on the Western Shore of Lake Champlain*, deals with certain igneous rock in the townships of the district named in which the most important phases of the great igneous body that forms the bulk of the Adirondacks are illustrated and photographic details not previously noted are adduced. The paper also appears in the Bulletin of the Geological Society of America.

The first number of *Tufts College Studies* comes without an editor's name, but a footnote to one of the articles, apparently editorial, bears the name of J. S. Kingsley. The number contains three papers—viz., The Anterior Cranial Nerves of Pipa, by G. A. Arnold; Ectodermic Origin of the Cartilages of the Head, by Julian B. Platt; and The Classification of the Arthropoda, by J. S. Kingsley. (Published at Tufts College, Mass.)

In *Observations on the Geology and Botany of Martha's Vineyard* (contributions from the Geological Department of Columbia College) the question is discussed by *Arthur Hollick* whether the island has been subjected to distortion and elevation by mountain-building forces, or whether its existence may be accounted for upon the same hypothesis by which we may account for the other islands—Long and Staten—as remains of the glacial morainal fringe. The author's conclusions are in favor of the latter hypothesis. The botanical section of the paper gives a list of a hundred and twenty-eight plants found growing on the island.

The *Ore Deposits at Franklin Furnace and Ogdensburg, N. J.*, are carefully described in a paper on that subject by *J. F. Kemp*, as to their history, location, surrounding, nature, and working. A list is given of sixty-six minerals occurring in them. The paper is a contribution from the Geological Department of Columbia College.

The object of the original edition of Mr. *H. W. Watson's Treatise on the Kinetic Theory of Gases* (Macmillan & Co., $1) was to set forth in a more systematic and in some cases a more simple form the demonstrations of the laws of the theory. In the present (the second) edition substantially the same ground is covered as in that one; but a more detailed treatment has been adopted, partly on account of historical interest, but mainly to avoid some of the difficulties experienced by the student in following out investigations of the great generality required in a more condensed treatment.

The matter of *Elements of Solid Geometry* (Macmillan & Co., $1.60) was used by the author, *N. F. Dupuis*, in annual courses of lectures to mathematical students, who were much interested. The subject is carried somewhat further than is usual in ordinary text-books of plane and solid geometry. The work is divided into four parts, which are again subdivided: 1. Dealing with the descriptive properties of lines and planes in space, of the polyhedra, cone, cylinder, and sphere. 2. Dealing with areal relations. 3. Stereometry and planimetry; and 4. The principles of conical or perspective projection. A collection of miscellaneous exercises is presented at the close of the work. The author expresses a high opinion of the value of synthetical solid geometry, in that it exercises the intellectual powers in the development of the theorems, the imagination in the building up of the spatial figures, and the eye and the hand in their representation.

White's Manual, in his *New Course of Art Instruction for the Fifth-Year Grade*,

includes the outline of the year's work in geometrical drawing—including sections on measurement, geometry, working drawings, development, decorative drawing, color, historic ornament, design, paper cutting, and model and object drawing. It is marked by the good qualities characteristic of all the books of this series. (American Book Company.)

A new volume of *Statistics of Public Libraries*, compiled by *Weston Flint*, has been issued by the Bureau of Education. It contains a list of three thousand eight hundred and four libraries in the United States having over one thousand volumes, arranged by States. Many of them are not what is commonly understood as public libraries, for they belong to schools, societies, and corporations, and a few are even set down as private. With each are given statistics concerning its age, size, income, growth, manner of use, ownership, etc. Prefixed to the list are summaries of these various statistics illustrated by comparative diagrams. A statistical list of public libraries in Canada is appended.

An edition, abridged for the use of junior students, of Baron *Roger de Guimps's Pestalozzi, his Aim and Work*, is published by C. W. Bardeen, Syracuse, N. Y., in his Standard Teachers' Library. The translation is by Margaret Cuthbertson Crombie, who has also appended brief, suggestive notes and a bibliography of Pestalozzi. (Price, 50 cents.)

The Art of Living in Australia would not be misnamed were it called The Art of Living Everywhere. It is, in fact, a treatise on hygiene and diet, by *Philip E. Muskett*, intended especially for Australia, but embodying principles that are generally applicable. Its main object is to call attention to the need of improvement in the food habits of Australians, who, the author is impressed, are living in special opposition to their semitropical environment. They are consumers of butcher's meat enormously in excess of any common-sense requirements and beyond any other people, while their fisheries are not developed, market gardening is "deplorably neglected," salads are "conspicuous by their absence," and Australian wine is "almost a curiosity." All this, he thinks, is wrong, and he tries to teach a better way. The Australians are not the only people who need instruction or admonitions on these subjects. In addition to the discussion of the principles of right living—including adaptation to the climate, ablution, bedroom ventilation, clothing, diet, and exercise—the book contains three hundred Australian cookery recipes and accessory kitchen information, prepared by an expert in such matters. (London: Eyre & Spottiswoode.)

In *Primary Elections* a study of methods for improving the Bases of Party Organization is presented by *Daniel S. Remsen*. Believing that reform should begin at the primary, the author would have the rules or laws of party aim to induce the largest participation of party members at that meeting. A method should also be provided which would enable minorities to elect their due proportion of delegates. Holding these principles in view, rules and methods are suggested which, while they may not be perfect, are believed to be on the right lines and such as will tend to make candidates feel responsible to the membership of their party rather than to any central power. (New York: G. P. Putnam's Sons' Questions of the Day Series. Price, 75 cents.)

John Phin dedicates his *Common-Sense Currency*—a practical treatise on money in its relation to national wealth and prosperity—to the farmers and mechanics of the United States, in the hope that the principle it sets forth may help them to detect the sophistries and avoid the traps of cheap-money demagogues, of avaricious and dishonest legislators who sell themselves to class legislation intending to cheat the workingman; and fanatics, honest, perhaps, but ignorant and enthusiastic, whose wild schemes contradict the fundamental principles of monetary science. (New York: Industrial Publication Company.)

The Diseases of Personality and *The Psychology of Attention*, two well-known and valuable works by the eminent French psychologist, *Th. Ribot*, are published by the Open Court Publishing Company, Chicago, as numbers 4 and 5 of their Religion of Science Library, at 95 cents each.

In a paper on *The Coming Railroad*, the Chase-Kirchner aërodromic system of transportation is described and its merits are set forth by the projectors, *G. N. Chase*

and *H. W. Kirchner*. The system includes an elevated track, with aëroplane sails as one of the sources of motor power. (St. Louis, Mo.)

Parts VIII and IX of *H. H. Bancroft's Book of the Fair* are devoted to the Woman's Exhibits, the Children's Department, and the Machinery and Agricultural Halls. (The Bancroft Company, Chicago. Price, $1 each.)

Entolai may be characterized as a "philosophical romance," or as a life history, with a religious element, described otherwise by the author, *A. M. Bourland*, as a letter to those he loves about science and the ideal. Its purport may be conceived from the dedication: "To those whose love of Nature has so thoroughly possessed them that they have been able to escape from every vestige of superstition, and as a consequence of which have embraced an unfaltering faith in the loving confidence in righteousness, that sustains all things, and rejoices in all truth." (Van Buren, Ark.: Lloyd Garrison.)

From Earth's Center: A Polar Gateway Message, is the title of a story embodying a thinly disguised teaching of some of the doctrines of the Edward Bellamy school, by *S. Byron Welcome*. A country within the earth, reached by means of a polar current, is supposed, where the ideal prevails of the conditions imagined by the dreamers of the class we have referred to.

Among recent bulletins of the United States Geological Survey is a *Report of Work done in the Division of Chemistry and Physics*, for 1890–'91, by *Frank W. Clarke*, which is occupied mainly with analyses of minerals and meteorites. Another bulletin is a *Record of North American Geology for 1890*, by *Nelson H. Darton*, being an alphabetical author and subject bibliography of books and essays in periodicals, dealing with North American geology, and received by the Survey in 1890. Works on general geological subjects, if printed in North America, are also included. *Samuel H. Scudder* describes in another bulletin, with three plates, *Some Insects of Special Interest from Florissant, Colorado*. Still another is a record of *Earthquakes in California in 1890 and 1891*, by *Edward S. Holden*. It consists of an observation of each shock made at the Lick Observatory, together with brief descriptions from many city and country newspapers in various parts of the State.

PUBLICATIONS RECEIVED.

Agricultural Experiment Stations. Bulletins and Reports. Alabama: Experiments in Crossing Cottons. Pp. 48, with Plates.—Delaware: Strawberries. Pp. 10.—Massachusetts: Analyses of Commercial Fertilizers. Pp. 8.—New York: On Legal Standard for Cheese. Pp. 20.—Preventing Leaf Blight. Pp. 6.—North Dakota: Weather and Crop Service for June, 1894. Pp 15.

Bendire, Charles. Nests and Eggs of New Birds from Island near Madagascar. Pp. 3.

Binet, Alfred. Psychologie des Grands Calculateurs et Joueurs d'Échecs (Psychology of Great Calculators and Chess Players). Paris: Hachette & Cie. Pp. 361.

Bird, Charles. Geology. A Manual for Students in Advanced Classes, and for General Readers. New York: Longmans, Green & Co. Pp. 429. $2.25.

Brinton, D. G. The "Nation" as an Element in Anthropology. Pp. 16.—On Various Supposed Relations between the American and Asian Races. Pp. 16.—The Alphabets of the Berbers. Pp. 11.

Call, R. E. On the Geographic and Hypsometric Distribution of North American Viviparidæ. Pp. 12, with Map.

Carus, Dr. Paul. The Nature of the State. Chicago: The Open Court Publishing Company. Pp. 56. 25 cents.

Cooke, Ebenezer, Editor. Pestalozzi's How Nature Teaches her Children. Syracuse, N. Y.: C. W. Bardeen. Pp. 206. $1.50.

Dall, William H. Monograph of the Genus Gnathodon, Gray. Washington: United States National Museum. Pp. 18, with Plate.

Dean, Lee Parker. The Evolution of Worlds from Nebulæ. Bridgeport, Conn.: The Marigold Printing Company. Pp. 84.

Earl, Alfred. Practical Lessons in Physical Measurement. New York: Macmillan & Co. Pp. 350. $1.25.

Farrington, Oliver C. An Analysis of Jadeite from Mogoung, Burma. Pp. 3.

Fewkes, J. Walter. A Study of Certain Figures in a Maya Codex. Reprint from the American Anthropologist. Pp. 16, with Plates.

Frankland, Dr. and Mrs. Percy. Micro-organisms in Water. New York: Longmans, Green & Co. Pp. 532. $5.

Frost, Edwin Brant, Translator and Editor. Dr. J. Scheiner's Treatise on Astronomical Spectroscopy. Boston: Ginn & Co. Pp. 482, with Plates. $5.

Gebhard, William Paul. On Testing House Drains and Plumbing Work. Pp. 8.—The Relations between Gas Companies and Gas Consumers. Pp. 7.—Artificial Illumination. Pp. 8.

Gill, Theodore The Nomenclature of the Family Poeciliidæ or Cyprinodontidæ. Pp. 2.—The Differential Characters of the Salmonidæ and Thymallidæ. Pp. 6.—The Relations and Nomenclature of Stizostidion or Lucioperca. Pp. 6.—The Nomenclature and Characteristics of the Lampreys. Pp. 4. All United States National Museum, Washington.

Houston, Edwin J. A Dictionary of Electrical Words New York: The W. J. Johnston Company, Limited. Pp. 669. $5.

Hudson, William Henry. An Introduction to the Philosophy of Herbert Spencer. New York: D. Appleton & Co. Pp. 234. $1.25.

Huxley, Thomas H. Discourses, Biological and Geological. New York: D. Appleton & Co. Pp. 388. $1.25.

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Jordan, David Starr. Factors in Organic Evolution. Leland Stanford Junior University, Palo Alto, Cal. Pp. 149.

Knowlton, F H. A Review of the Fossil Flora of Alaska. Washington: United States National Museum. Pp. 36, with Plate.

Le Conte, Joseph. Memoir of John Le Conte. Berkeley, Cal. Pp. 24.

Mearns, Edgar A., M. D. Description of a New Species of Cotton Rat from New Mexico. United States National Museum. Pp. 2.

Merrill, George P. On the Formation of Stalactites and Gypsum Incrustations in Caves. Pp. 5, with Plates.—The Formation of Sandstone Concretions. Pp. 2, with Plate.

Michigan Mining School. Reports of the Director, 1890–'92. Pp. 102.

The New Science Review. Quarterly. Vol. I, No. 1, July, 1894. Philadelphia: The Transatlantic Publishing Company. Pp. 128. 50 cents. $2 a year.

New York Society of Pedagogy. Magazine and Book Reference. Quarterly. March and June, 1894. Pp. 8 and 10.

New York State Board of Charities. Twenty-seventh Annual Report. Pp. 651.

Otken, Charles H. The Ills of the South. New York: G. P. Putnam's Sons. Pp. 277.

Pammel, Prof. L. H. A Lecture on the Pollination of Flowers. Des Moines, Iowa. Pp. 57.

Paret, T. Dankin. Emery and other Abrasives. Philadelphia. Pp 36.

Pennsylvania, University of. Contributions from the Zoölogical Laboratory. Philadelphia. Pp. 68.

Rathbun, Mary J. Notes on Crabs of the Family Inachidæ. Pp. 32.—Crabs (New Species) from the Antillean Region. Pp. 4. United States National Museum.

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POPULAR MISCELLANY.

Spermophiles.—The destructive animals that form the subject of Vernon Bailey's Bulletin (Department of Agriculture) on the prairie ground squirrels of the Mississippi Valley, belong to the genus *Spermophilus*, and are commonly known as spermophiles. The name is derived from the Greek words σπέρμα, seed, and φιλεῖν, to love, in allusion to the fact that seeds form a large proportion of the food of the species. In the Old World the spermophiles are known as sousliks, while in America they are popularly called gophers or ground squirrels. The term gopher, however, belongs properly to a very different group of animals, to which it should be restricted, namely, the pocket gophers, which have external cheek pouches, and resemble the moles in living under ground and throwing up little mounds along the courses of their subterranean tunnels. Ground squirrel is a less objectionable name, because these animals really are ground squirrels; the term is, however, commonly applied to the chipmunks belonging to the related genus *Tamias*. *Spermophilus* is a

large genus, and is found throughout the greater portion of the north temperate region of both hemispheres from eastern Europe across northern Asia and over the western two thirds of America. About thirty-five species and subspecies are found in the United States, most of which are restricted to the arid and subarid region west of the Rocky Mountains. Throughout their range, wherever the land is under cultivation, they are among the most destructive of mammals, feeding on grain, fruit, and garden vegetables to such an extent that the losses from their depredations must be counted in hundreds of thousands of dollars. Several States have paid large bounties for their destruction, without materially reducing their numbers; and numerous bulletins of agricultural experiment stations have dealt with means of destroying them. Prof. C. P. Gillette has shown, from examination of their stomachs, that the thirteen-striped spermophile is not an unmixed evil, for, besides large quantities of grain, it eats numbers of grasshoppers, wireworms, and other noxious insects, whence he concludes that a large proportion of its food is made up of insects that seem to consist almost exclusively of injurious species, and adds that "the squirrels would be a most valuable adjunct to any cornfield after planting if some method could be devised to prevent them from taking the corn."

Pin Wells and Rag Bushes.—A paper on Pin Wells and Rag Bushes was read in the British Association by Mr. E. Sidney Hartland. Prof. Rhys has lately brought together a number of instances, in Wales and the Isle of Man, in which persons frequenting sacred wells for the cure of disease and other purposes have been in the habit of throwing pins into the water, stuffing rags under stones, or tying rags upon adjacent trees; and he has discussed the reasons for these practices, suggesting that the pins are offerings and the rags are vehicles for the transfer of the disease. These suggestions were discussed in Mr. Hartland's paper, who compared the practices mentioned by Prof. Rhys with ancient and modern observances in Europe and other parts of the world at sacred wells, crosses, trees, temples, and other objects of superstition. He preferred the hypothesis that the object of these usages was to effect unison between the worshiper and the divinity, which was to be effected by the perpetual contact with the god of some article identified with the worshiper. Prof. Sayce mentioned evidences of similar customs in Palestine and Egypt. In the latter country the rags were hung up by the Bedouin and not by the native fellaheen. Colonel Godwin Austen said that throughout the Himalayas, from Cashmere to far in the East, in Bhotan, he had observed the custom of placing rags upon cairns, especially at the passes. Dr. Robert Mensal, president of the section, said that, although the customs mentioned in the paper might seem ridiculous, they all had a meaning, and the science of folklore, as interpreted by men like Mr. Hartland, was enabling us to find out what that meaning was.

Plants and their Seasons.—The philosophy that underlies the association of certain groups and types of plants with certain definite seasons of the year is the subject of a study by Henry L. Clarke, of the University of Chicago, the flora east of the Rocky Mountains alone being considered. The problem is defined: "From March to November, each month brings a new prospect in field and forest, and every careful observer can feel in this succession of forms a harmony into which any decided change would break discordantly. . . . To say that the fall flowers are not the spring flowers or those of summer are neither, merely because they have chosen at random this season or that, is neither science nor common sense. The truth is forced upon us that the various groups of flowering plants are not scattered indiscriminately from one end of the season to the other, but are regulated by definite scientific principles; and that just as relations can be traced between physical geography and geographical distribution, or between plant history and geological periods, so there is a connection between the relations of season to season and the relations of their respective floras." After a careful examination of the phenomena in detail, Mr. Clarke deduces the conclusion that "from early spring to late autumn there is a progression in the general character of the flower groups, from the lower to the higher, successive groups succeeding each other in time, paral-

lel groups coming synchronously. And the later in order may be types of a character of development, or they may be specializations of a group whose normal forms belonged to an earlier season. In their blooming season the more perfect succeed the more simple; the aberrant, the normal; the specialized, the generalized. But with the general observation arise certain modifying conditions"—which are mentioned.

Unsanitary Positions.—In a paper on Some Derangements of the Heart and Stomach produced by the Unusual Position of Children in School, read before the Académie de Médecine of Paris, Dr. Motais pointed out the effects of that attitude in which the pupil seats himself on the ischial tuberosity, supporting himself by leaning on the left elbow and stooping forward, so that the trunk of the body then develops an antero-lateral curvature. The result is, firstly, that by the lateral inclination the border of the false ribs on the left side descends until it is in contact with the iliac crest. The larger curvature of the stomach is thus pressed upon the spleen and general mass of the intestines; secondly, by bending the body so much anteriorly a fold is formed at the upper part of the abdominal wall, and the anterior surface of the stomach follows the curve. These conditions produce a mechanical hindrance to the movements of the cardiac stomach. The function of the thoracic viscera is equally interfered with by means of the anterior curvature owing to the drawing together of the ribs and also by the descent of the left half of the diaphragm toward the upper border of the stomach. The difficulty thus afforded to respiration reacts on the heart, the contractions of which are, moreover, mechanically hindered by the distortion of the thoracic cavity. The neck is necessarily somewhat twisted, and the large vessels at the root, therefore, are submitted to a certain amount of torsion. The effect of the attitude described above is especially marked when an organic affection of the heart exists. Dr. Motais is also of the opinion that this position is a strong pathogenic element protracting the duration of dyspepsia. He has found that if children who suffer from this complaint are made to assume a correct posture while in school the symptoms subside more rapidly than when such a precaution is not taken. The same observations are applicable to adults engaged in sedentary occupations, and Dr. Motais laid great stress on the point that the medical man, when treating cases of chronic heart or gastric disease, should give his patients directions as to the posture to be assumed when much sitting is necessary.

Australian Dingoes.—A colony of dingoes or Australian wild dogs recently bred in the *Jardin d'Acclimatation* in Paris, and two of the brood of four lived. This animal has very dense hair, which is thicker in winter than in summer, erect and mobile ears, long and pointed muzzle, and tufted tail, which hangs down when the animal is at rest and is carried curled over the back when its attention is attracted by any noise. It has well-developed senses of hearing and smell. Its average height is perhaps about twenty inches, but different specimens vary greatly in size. Its hair is usually red on the back and head, growing lighter and lighter on the inside of the thighs and limbs. Some individuals are of uniform color; others have white on the paws and the end of the tail. The dingo inhabits the forests, heather, and steppes of the whole Australian continent, where it lives upon kangaroos and whatever other animals offer to its greedy appetite; and it plays havoc with the flocks of the colonists, who war upon it without mercy. Dingoes are frequently domesticated, but, according to Bohm, they retain all their wild instincts in that condition, and readily attack any animal that comes within reach of them. The two puppies in the Jardin d'Acclimatation were cared for with much solicitude by their mother, who did not leave them, but permitted the attendants to change their litter and handle them without objection. She refused all food but raw meat, but occasionally drank milk. She played freely with the other dogs around the kennel, some of which were of fine breeds; and when any conflict arose with regard to food, knew perfectly well how to defend herself. When the young were a month old, the mother, finding they did not require her constant attention, gave way to her vagabond habits. She made her way out of the box in which the little ones were confined, and

left them to wander around the garden, only returning to give them suck. She at length escaped from the garden to Neuilly, but returned of her own accord. For fear of losing her entirely, she was separated from her young and fastened up. The young are very familiar, and play all day long with the other young dogs.

Thrifty Birds.—A curious illustration of the industrial instincts of animals, given in M. Frédéric Houssay's book on that subject, is afforded by the California woodpecker, which, though an insect eater, stores away for its winter supply food of an entirely different character, not so subject to decay. It collects acorns, for which it hollows small holes in a tree—a hole for an acorn—into which the acorn is exactly fitted, ready to be split by the strong beak of its owner, but too tightly held to be stolen by other birds or squirrels. Another woodpecker, in Mexico, stores against droughts, selecting the hollow stem of a species of aloe, the bore of which is just large enough to hold a nut. It drills holes at intervals in the stem and fills it from bottom to top with nuts, the separate holes being probably made for convenience of access to the column of nuts within. The common ants of Italy store oats and other kinds of grain in chambers which they make of about the size of a watch. They have a way of keeping the grains from sprouting with which we are not acquainted; and if they are removed, the seeds sprout. When they wish to use their store, they allow the grains to germinate till the chemical change takes place in the material that makes its fermenting juice suitable for their digestion. They then arrest the process of change by destroying the sprout, and use the stock of glutinous sugar and starch as their main food in winter.

Atmospheric Dust and Air Colors.—Having continued his observations on dust particles in the atmosphere in connection with other meteorological phenomena, Mr. John Aitken has now exceeding fifteen hundred observations, to produce which required the testing of fifteen thousand samples of air. The list includes, besides Great Britain, observations made in the south of France, at Hyères, Cannes, and Mentone, and at the Italian lakes. At none of the places in these districts was pure air ever met with. On the slopes of Monte Motterone, at Baveno, with the wind blowing up the slopes and carrying up the impure air, the amount of dust at two thousand feet was reduced only to 0·64 of the number at low level, while if the wind was from other directions it was reduced to 0·3. The conclusion that the descriptions given by many writers of the beauty of the coloring on earth and sky seen at high level at sunrise and sunset are much exaggerated is confirmed by the observations on the Rigi Kulm. During five years no coloring at sunrise or sunset was witnessed from this point equal to what is frequently seen at low level. The sunset colors are shown to depend very much on the amount of dust in the air. When the atmosphere is comparatively free from dust the coloring is cold, but the lighting is clear and sharp; and when there is much dust, there is more color on the mountains and clouds and in the air itself, and the coloring is warmer and softer. At high level the coloring is more feeble and of shorter duration. A thick veil of haze seemed to hang in the air between the observer and the mountain on all days when the number of particles was great, and it became very faint when the number was small. The condition of the air on the occasions of the different visits to the Rigi varied greatly. The clearest days, with the lowest numbers of particles, were when the wind blew from the Alps. The daily maximum on the Rigi did not appear on all days. Winds from pure directions generally prevented it, either by checking the ascent of the valley air, or by the valley air being pure, or by the pure valley air not being much heated by the sun and therefore having but little tendency to rise. It was very marked when the wind was from the plains. The hour at which the rise in numbers began and the hour of maximum were very irregular. The amount of the daily maximum varied greatly; sometimes it was only two or three times the morning number, while it at other times exceeded it eightfold. In the observations at Kingairloch, in Argyllshire, certain abnormal readings of dust particles were always accompanied by certain conditions of weather. If the sky remained clouded all day, the numbers were always low during the whole of

the day; but if breaks formed in the clouds, the numbers began to rise, and the increase was very much in proportion to the amount of clear sky. It also appeared that these abnormal readings came more frequently with anticyclonic than with cyclonic circulation. The fact that during the days of abnormally high readings the air did not become hazed to anything like the extent indicated by the number of particles, seemed to suggest that these nuclei are of molecular dimensions, and it is even possible they may not be nuclei at all while the air is dry, and form nuclei in saturated air. The Kingairloch observations, when arranged in tables, showed that nearly double the number of particles are required to produce the same amount of haze when the air is very dry as when it is damp. The transparency of the air was also noticed to be roughly proportional to the wet bulb depression. It is not the amount of vapor in the air that produces this effect, but the nearness of the vapor to the dew point, which seems to enable the dust particles to condense more vapor by surface attraction and otherwise, whereby, by becoming larger, they have a greater hazing effect. In all densely inhabited areas the air loses its purity, and in all uninhabited areas it tends to regain it; but all uninhabited areas are not equally good purifying ones. Much of the dusty impurity discharged into our atmosphere from artificial sources, by volcanoes, and by the disintegration of meteoric matter, falls to the ground, but much of it is so fine it will hardly settle. The deposition of vapor on these small particles seems to be the method adopted by Nature for cleansing them away; they become centers of cloud particles and ultimately fall with the rain.

The Labors of a Woodpecker.—John B. Smith, of Rutgers College, New Jersey, writes to Garden and Forest that he has received a piece of white oak, thirteen inches in length and three inches in diameter, containing four holes made by a woodpecker. Each of the holes is nearly or quite an inch wide with the grain, and a trifle less across the grain, narrowing to the bottom of the holes; each of them reaches into the center of the tree and into an insect burrow. In order to reach one of the larvæ which were the object of its researches, the bird was compelled to make two attempts, having missed the point on the first attempt. The larva for which all this work was done measured about three quarters of an inch in length, with a diameter of perhaps one sixteenth of an inch, and would hardly serve to make more than a scant mouthful for even the smallest woodpecker. It must have taken the bird at least half an hour of persistent work to make each hole, or at least an hour to secure this one larva, weighing only a few grains. It seems, Mr. Smith remarks, as if it would be almost impossible to gain from such a larva a fair return in food value for the energy expended in getting at it, especially where it is necessary to make two efforts to recover one mouthful. In the other burrows the bird was more successful, and gained the larva at the first attempt.

A Forest in Nicaragua.—With the exception of a few clearings, the entire region of the San Juan River, Nicaragua, is described by B. Shimek, in his report to the Natural History Society of the State University of Iowa, as covered with typical tropical forests. They are almost impenetrable, except with the aid of the *machete*, with which the traveler must literally tunnel his way in many places through the walls of vegetation. The trees, many of which are very tall and from eight to fourteen feet in diameter, are not quite so closely placed together as those of our northern forests; but the intervening spaces are covered with shrubs and vines and numerous other plants, so that, particularly in lower places, dense jungles are formed. Moreover, each tree is a veritable garden in itself. The masses of parasites and epiphytes which cover the larger branches of the trees, and often extend down the trunk and along the smaller branches to their very tips, form a perfect canopy overhead through which the sun's rays never penetrate. Ferns, bromelias, orchids, mosses, and many other plants crowd their hosts with a dense mass of multicolored vegetation. In their active struggle for existence with more powerful neighbors of the forests, these plants have probably gradually ascended, in their search for the sun's light, to the upper branches of the very neighbors which sought to crowd them out, thus transferring the struggle from the surface of the soil to the air above. So firmly

is this habit fixed, however, that, even where a tree stands alone, its trunks and branches are almost invariably covered with these plants. Their abundance and variety may be judged from the fact that upon a single jicara tree, not more than twenty feet high, which stood in a clearing near Castillo, the author counted forty species of epiphytes. The vines and underbrush are less abundant on the higher grounds, and moving about is consequently easier. But, whether the place is high or low, the same deep, dark, reeking forest spreads over all. Two facts strike the observer as peculiar, at least during the season which the party spent at Castillo—the comparative scarcity of brilliant flowers, and the failure of the plants of one species to mass together. The comparatively small number of conspicuous flowers is a disappointment to him who expects to find a mass of brilliant bloom in these tropical forests; not so much because these flowers are really wanting as because the flowering period of most of the species is rather long, and for the further, perhaps more important, reason that the flowers which do appear seem insignificant when compared with the sea of green that covers everything. No less striking is the fact that, as a rule, specimens of any one species do not mass together to the exclusion of other species, excepting sometimes along the watercourses. Different kinds of trees are mingled together in endless confusion, and no "groves" of any one species, such as we are familiar with in the North, occur, nor can any species, as a rule, ever be said to be prominent. The same is true of smaller plants; and the collector is not only bewildered by the variety of plants that come in his way, even in a restricted locality, but is also provoked by the scarcity of specimens of most of the species. Along the river banks, however, palms, grasses, etc., often take possession of large tracts.

Origin of Clays.—Clay, says Mr. Robert T. Hill, in his report on that material in the "Mineral Resources of the United States," is the immediate or ultimate product of the decomposition of feldspar. Feldspar is a constituent mineral of all the igneous rocks of the earth, and is especially abundant in the older granites and gneisses. By its decomposition, which occurs principally under the action of water, the soda, lime, potash, and other alkaline constituents of the feldspar are removed in solution, leaving the aluminum silicate and quartz as a residuum, commercially known as rock kaolin—a non-plastic material which, when free from iron, is also known as porcelain clay. Water, in Nature as in pottery, is the chief agent in clay working, and, besides its original action in decomposing the feldspar, it transports and grinds the original kaolin, and deposits it, in various degrees of purity or mixture, in secondary localities as a sediment. Clay material thus produced is known as sedimentary or transported clay, and, with the exception of some of the kaolins which have not been far removed from their place of origin, is more or less plastic. The washing and grinding of clays by clay-workers is a repetition of fundamental geologic processes of erosion, corrosion, and deposition constantly going on in Nature; and the geologist can see in the flumes and settling tanks of the potter a laboratory demonstration of the principal agencies which he studies. The clay material resulting from the decay of feldspar may be broadly classified under the two general heads of residual and sedimentary. The residual material is that which is found in the original place of occurrence of the decomposing feldspar, and may possess many physical aspects, sometimes occurring as a firm or crumbling rock, resembling decomposed granite, or again as a fine, white, non-plastic clay or kaolin. It is usually accompanied by quartz, a material not essentially injurious, which can be removed, if that is desired, by washing. The sedimentary clays are those which have been removed from their place of origin and redeposited in water. They embrace all degrees of mixture and purity, and may be either kaolinitic or plastic.

Value of a Geological Survey.—On the 18th of April, 1894, the geological survey of Alabama attained its majority—twenty-one years—under the present management, with Eugene A. Smith as State Geologist. By way of memorial of the occasion maps are in course of preparation showing the condition of our knowledge of the geology of the State at the beginning and at the end of the period, 1873 to 1894; and besides these, tables showing the relative amounts of raw

materials and of finished products from the mineral resources of the State at the same times. A sketch of the history of the surveys in the State has also been prepared by Mr. Smith. They were begun with the appointment of Michael Tuomey as Professor of Geology in the State University in 1847, when he was expected to spend about four months in each year in field observations. The next year he was made State Geologist. An appropriation was first made for the survey in 1854. Prof. Tuomey died in 1857; his last reports were edited and brought out by Prof. John W. Mallet, chemist to the survey; and the survey was discontinued. The second survey, under Prof. Smith, was begun in 1873. A detailed account of its several stages and departments, with the papers published by it, is given in the memoir. The co-operation of the United States survey with the State survey, begun in 1879, is recognized as having been "very distinctly advantageous." "In retrospect one can, however," says Prof. Smith, "easily see how these benefits might have been materially increased by more frequent conferences and consequently more thorough mutual understandings and adjustments." The survey has cost during the past eleven years $75,847, or an average of about $6,900 a year. For the whole period of twenty-one years during which the survey has been active, the aggregate cost has been $90,597, an average of $4,314 per annum. Since the organization of the survey, the tax rate of the State has been reduced over fifty per cent. without diminishing the revenues. The increase in the value of property in certain sections of the State that has rendered this possible has been due in the main to the development of the mineral wealth, and to this the survey publications have contributed a certain undetermined share. Some of the regions of the State in which the mining of coal and iron had since assumed vast proportions were untouched when the earlier reports directed attention by maps, analyses, and otherwise, to their great resources; and very recently the survey has demonstrated the existence of profitable areas in the coal measures heretofore untried; has pointed out a source of wealth in the phosphatic marls of certain sections; has shown that gold may be mined with profit at many points; has demonstrated that clays suitable for the manufacture of fine porcelain ware, fire brick, tiles, and other articles occur in practically limitless quantity in many sections; and has pointed out the places where good marbles and building stones may be had for the quarrying. All these have as yet not been turned to account.

Meanings of Japanese Fans.—The study of Japanese fans is regarded, in Mrs. Charlotte M. Salwey's book on the subject, as substantially the study of the history, religion, etiquette, daily manners and customs, peace and war, trade, games, and literature, in fact, of the whole civilization and art of the country. From the sixth century downward fans were a part of the national costume. Every fan belonging to every rank had its meaning, and was used in its own particular way according to a strict code of etiquette. The flat fan, or *uchiwa*, was introduced into Japan by the Chinese, and has been made in different shapes and used in many different ways. The cheapest and most usual forms are common objects in the West. One of its most curious varieties is the iron war fan, invented in the eleventh century for the use of military commanders, either for direction and signaling or as a shield for defense. It is made of leather and iron. The water fans are made of bamboo and thinly lacquered, so that they may be dipped in water to secure extra coolness while fanning. Another kind of *uchiwa* is the revolving white fan, which whirls around its stick and can be rolled up. Another strong, flat paper fan is used as bellows to blow the charcoal fire in the kitchen. The *agi* are folding fans; among them the *hi* wood fans are the most beautiful. They are painted with flowers and tied with white silk. Anciently they were hung with artificial flowers made of silk. These were the court fans, and different flowers were appropriated by different great families, so that a fan answered the purpose of armorial bearings. Folding fans also served the purpose of ensigns in war, and an enormous fan, *mita agi*, giant fan, was carried in processions in honor of the sun goddess. Children and dolls have fans of their own. Dancers and jugglers carry peculiar fans. The tea fan,

Rikiu, was used at the ancient tea ceremony for handing little cakes. The *agi* is now frequently made useful by being covered with engraved maps of the different provinces. Sometimes a fan case holds a dagger. Preachers make points in their speeches by sharply opening or shutting their white fans. Album fans, on which poems are written, are a curious feature in the life of Japan. Many old legends are told again by the arrangements of houses, flowers, figures, and birds painted on the faces of fans. An endless etiquette is involved in the use of fans. With the Japanese, in fact, the fan is an emblem of life. The rivet end is regarded as the starting point, and as the rays of the fan expand, so the road of life widens out toward a prosperous future. The *agi* is said to have originally taken its shape from the remarkable mountain Fusiyama, which represents to the Japanese all that is beautiful, high, and holy.

Artificial Birds for Women's Hats.—According to a writer in the London Spectator, a change has come over the minds of women in respect to feathers; and while these pretty ornaments continue to be worn, the objections to the wanton sacrifice of birds in order to procure them have so far prevailed that substitutes have been found for those kinds to obtain which birds were killed. While the egret plume—the finest of these feathers—is still unapproachable as an ornament, the milliners say that ladies object to buying the real article, "because it is cruel," and demand artificial substitutes, or are contented with less perfect plumes, and sham "ospreys," as they are called, are made in ways it is difficult to determine. Some are fashioned from split quill feathers of a larger heron. In others even a microscope fails to show the process of manufacture. Besides substitutes for the "osprey," "all kinds of composite feather decoration, perfect for the purposes to which it is applied, are now used for hats and bonnets, and a naturalist in a milliner's shop finds himself confronted with a hundred varieties of plumage never seen in Nature, but excellent in art, for which it would puzzle any one but the *plumassier* or the taxidermist to find a name. The era of stuffed birds and natural wings adorning headdresses is almost over. Not long ago, for instance, terns were a favorite ornament. The whole bird was used. Large hats were fashionable, and two or three of the 'sea swallows' were grouped on a single head. . . . Now the milliners have discovered a substitute with which no lover of birds can quarrel, and which reflects no little credit on their craft. Poultry feathers, in some cases of natural colors, but more often dyed to tints suited to the material with which they are worn, are made up into plumes, wings, coronets, and pompons, with a grace and variety of outline which harmonize with the modeling of the human head far better than the natural bird forms. Wings of domestic pigeons, often mottled with exquisite shades of gray or roan, are still used; but as the pigeons themselves are destined for food, no one can quarrel with the disposition made of their plumage. The greater part of modern head gear, however, is decorated with dyed cock feathers, or 'coque' feathers—pronounced to rhyme with 'oak'—as the milliners prefer to call them. The use of the cock's feathers has been a gradual dedelopment. In John Leech's day they were suggested by the plumes worn by the Sardinian troops in the Crimean War, and were worn in ladies' felt hats, somewhat of the 'field marshal's' pattern. These were only the dark-green tail feathers. But the piles of 'Mercury wings' of all colors—plain or decorated with tinsel or jet—which filled the milliners' shops last summer, and which still hold their own, are an immense advance on the cock-feather plumes. Some of these wings are so well made that, except for want of proportion between the primary and secondary feathers, even a naturalist's eye might be deceived. Regarded purely as an ornament, they are preferable to the natural arrangement, for their construction admits of endless adaptation." Women's fondness for feathers may be credited with being the means of preserving one and that the largest species of living bird from extinction, for it has offered the inducement for which ostrich farms have been established and are maintained.

The Australian Diprotodon.—Interest was excited in the recent meeting of the Australasian Association by an account, by C. W. de Vis, of the diprotodon, fossil bones of which have been found in Lake Mulligan,

and its times. The diprotodon was in some respects like a wombat, but seems to have been less capable of rapid motion. The spongy texture of the bones of the skeleton indicates that it frequented lakes and marshes. Two species of the fossil have been found in central Australia—one about six feet high and ten feet long, and the other about five feet high and eight feet long. The arid central plains of the present were occupied in diprotodon times by vast extents of luxuriant forest and richly vegetated districts, well watered by wide rivers. The marsupials were even then the dominant type of life in Australia; lizards were also numerous, and some were of unusually large proportions; megalania, for example, are extinct "guana," from eighteen to twenty feet in length. Alligators and turtles of forms now extinct infested the waters, and among the fishes was the still existing ceratodus. The remains of a varied bird fauna have been preserved in the same deposits. This fauna included some ancestral forms connecting, on the one hand, the wingless birds of New Zealand with the Australian emus, and on the other hand the Australian birds with the New Zealand apteryx. The author was inclined to attribute the disappearance of so many of these forms of ancient life quite as much to senile decay as to altered climatic influences.

Waters of the Colorado Coal Field.—The water supply of the Colorado coal field of Texas, though not abundant as a whole, is represented in the report of Messrs. N. F. Drake and R. A. Thompson, of the State Geological Survey, as usually ample and sufficient for all demands and purposes. Numerous springs burst forth from the strata and many overflowing rivers and creeks traverse the breadth of the region, which afford water unsurpassed for wholesomeness and purity. When sufficient care is exercised in their location, water for drinking purposes can be obtained from wells in nearly all parts of the area, though when bored to excessive depths the water contained is, as a rule, contaminated with salt, oil, and other impurities that exist in the strata. The Colorado, Concho, and San Saba are the only rivers flowing through the district. The Colorado, having for its origin the great springs flowing out from the eastern slope of the Staked Plains, and being re-enforced at every point of its course, furnishes an unsurpassed supply of water to its riparian inhabitants. Except in times of what is called the "red rises," its water is pure and clear. These red rises are caused by heavy rainfalls in the region of the Red Beds of the Permian and Triassic in which the Colorado heads. The beds consist of conglomerates, fine-grained sandstones, and impervious arenaceous and highly calcareous red clays and shales, which disintegrate rapidly under the action of rainfall, and the disintegrated material is borne down by the rapid current of the river. Owing to the fine-grained and impervious nature, especially of the clays, they do not silt rapidly, and the material is held in suspension by the water long after it has passed the limits of the Red Beds. The Colorado flows over numerous little falls and rapids while pursuing its course across the heavy beds of limestone and sandstone which extend from the western boundary of the Permian to the southern limit of the Upper Cretaceous. This shifting turns its every particle again and again to the purifying action of the atmosphere, and the immense beds of stiff and tenacious clays and shales do not impair its clearness. The water flowing over the limestone becomes highly charged with carbonic dioxide in solution, which oxidizes much of the organic matter that may contaminate it, and thus renders it purer. The water of the Concho River is of the same character as that of the Colorado. The San Saba runs about forty miles through the carboniferous formation. Few of the creeks or smaller streams are ever-running, but the majority of them flow except in the driest seasons. Water is obtained in them from numerous large, deep holes, the majority of which remain filled through the year, and in which it does not become stagnant.

St. Gregory of Nyssa and the Nebular Hypothesis.—In a study, in the American Ecclesiastical Review, of the exegeses by the early Christian writers, especially those of Alexandria and Cæsarea, the Rev. John A. Zahm, of the University of Notre Dame, sets forth that they were the first to propose or develop a true theory of the origin of the world, and to lay the foundations of cosmogonic doctrines that are usually credited to

investigators of a much later epoch. Thus, in the Hexæmeron of St. Gregory of Nyssa, "is developed, in unequivocal terms, the same hypothesis that has so long been regarded as the special glory of the Système du Monde of Laplace." According to this saint, the words, "In the beginning God created the heaven and the earth," "do not refer to the creation of the heavens and the earth, as we now behold them, and still less do they signify the creation of the creatures—plants, animals, and man—that inhabit the earth. They refer rather to the creation from nothing of the primitive, cosmic matter—from which all forms of matter, organic and inorganic, were subsequently fashioned. The saint finds a warrant for this interpretation in the words of Genesis itself. For, according to the inspired writer, the earth, after the first creative act, was 'void and empty,' or, as the Septuagint has it, 'invisible and discomposed.' In the beginning, then, all things were created potentially rather than in act. They were contained naturally or in germ in the invisible and unformed matter that came forth from nothing in response to the divine *fiat*. The first sentence of Genesis tells us of creation, properly so called, the *opus creationis* (or work of creation). That which follows refers to the formation from pre-existing matter of all the bodies of the universe. This is what theologians call the *opus formationis* (work of formation), and what modern scientists term the development of evolution. In the beginning, therefore, according to St. Gregory of Nyssa, all was in a chaotic or nebulous state. But it did not remain so, because the Almighty put it under the action of certain physical laws by virtue of which it was to go through that long cycle of changes of which science speaks. . . . The manner in which the saint expresses himself when treating of this subject is, considering the scientific knowledge of his time, simply marvelous. He seems to have had an intuitive knowledge of what could then not be demonstrated, and of what could be known only after the revelations of modern geography and astronomy. . . . After the primitive, nebulous matter of the cosmos was created, certain molecules, St. Gregory teaches, began, under the influence of attraction, to unite with other molecules, and to form separate masses of matter. In the course of time, these masses of matter, rotating on their axes, gave off similar masses, which assumed a spherical form. In this wise were produced the sun and moon, stars and planets. . . . In this brilliant conception, in which he could but divine what Laplace and his compeers have rendered all but certain, St. Gregory recognized the existence of laws which he was unable to detect, much less to comprehend. These were the laws made known long ages afterward by the investigations of Kepler, Newton, and Plateau, and the laws of chemical affinity which have thrown such a flood of light on the secret operations of Nature. . . . No exegetist has ever been more happy in the employment of the scientific method; no one has ever had a keener appreciation of the reign of law and order which obtains in the universe. No one has ever realized more thoroughly that the cosmos as we now see it, far from being the work of chance, is the result of a series of divine interventions, is the outcome of a gradual evolution of that primordial matter which God created in the beginning; which he then put under what we call laws of Nature; and which he still conserves by his providence."

A Monument to Lavoisier.—A proposition was published by Gustavus Hinrichs, of St. Louis, on the 8th of May of this year—it being the centenary of the death of that chemist—for the erection by the chemists of the world of a monument to the memory of Lavoisier, "the Copernicus of chemistry." "It is now well understood," Mr. Hinrichs says, "that the claims of Lavoisier to universal recognition depend in no way upon the title to the discovery of any new substance, however important. Both England and Sweden have appropriately honored their discoverers of dephlogisticated air by imposing monuments. The well-known fact that both these eminent chemists remained faithful and aggressive phlogistonists till death is an all-sufficient proof that their discovery is in no way essential to the glory of Lavoisier. The life work of Lavoisier was deeper and broader than the discovery of any new substance, and affected the very foundation of the science of chemistry. He broke through the veil of mere

phenomena, and discovered beyond it the reality of chemical processes." Some of the contemporaries of Lavoisier may have been more skilled experimenters in some directions, and no doubt he left much for his followers to do. "Nevertheless, his *Traité Élémentaire de Chimie* is unquestionably the first rational exposition of the science of chemistry, entirely resting on experimental evidence, largely his own, and admitting to the entities of matter nothing that was not actually produced; and since that day chemistry is the science of the real elements."

NOTES.

In the present course of thought and life Prof. George E. Howard sees a crisis which is determining the character of the modern university. Thus there is a growing tendency to abandon the traditional assumption that there is an essential difference in the scholastic value of studies. A new test of scholastic fitness has arisen—the test of life. All things are in process of development; whole departments of knowledge, hitherto unheard of in the schools, have received recognition. Old subjects which were thought dead have turned out to be but sleeping. Thus philosophy and the classics, subjected to the comparative method, are being made more productive than ever before for social good.

A report on the climatology of the city of Mexico, based upon hourly observations continued through sixteen years (1877 to 1892), is published by Señor Barcena, of the meteorological observatory there. The mean annual temperature is 15·4° C. The mean monthly temperature ranges from 12° C. in December to 18·1° C. in May. The highest temperatures in the shade range from 23° C. in December to 31·6° C. in April; while the limit of lowest temperature runs from —2·2° C. in December to 8·2° C. in August and September. The most rainy months are those from June to September.

A "Bird day" has been established in some of the schools of Oil City, Pa., the object of which is to promote "preservation of American birds from the women who wear them and from the small boy." The literary exercises are similar to those customary on Arbor day.

Frogs are credited by Dr. Romanes, in his Animal Intelligence, with having definite ideas of locality. A Japanese correspondent of Nature says that the same fact has been noticed of old by the Japanese and Chinese. Rejoan Terashima, in his illustrated Cyclopædia of the Three Systems of Japan and China (completed in 1713), says that "when frogs are removed far, they always long after the original locality; hence the Chinese name Hia nia." For similar reasons the Japanese call them "Kaeru," meaning *return*. This author is confirmed by the lexicographer Shisei Tagawa.

Experiments made upon certain fresh-water crustaceans, says the International Journal of Microscopy, show that they are sensitive to sounds corresponding to more than forty thousand vibrations per second (sounds that we can not hear), and to ultra-violet rays that we can not perceive. Now, all the rays that we can perceive appear to us with definite colors, and it should be the same with these animals; so that it is probable that they see colors that are unknown to us, and that are as different from those that we are familiar with as red is different from yellow or green from violet. It follows from this that natural light, which seems white to us, would appear colored to them, and that the aspect of Nature would be entirely different to them from what it is to us. It is possible, therefore, that to certain animals Nature is full of sounds, colors, and sensations that we have no idea of.

An English committee of sportsmen and naturalists is taking in hand the protection of South African mammals—the giraffe, zebra, eland, gnu, koodoo, and other antelopes —against their threatened extinction. A suggested method of accomplishing this is to secure an inclosed park of about a hundred thousand acres.

In a new process for coloring leather by electrical action, the hide is stretched upon a metallic table and covered, except at the edges, with the coloring liquid. A difference of potential is established between the liquid and the metallic table. The effect of the electric current is to cause the pores of the skin to open, whereby the coloring is enabled to penetrate deeply into its tissue.

A bust of Charles Waterton, the naturalist and South American traveler, executed by the late W. Hawkins in 1865—the year in which Waterton died—has been presented to the Linnæan Society of London by the trustees of the late Mrs. Pitt Byrne. The only accessible portrait of Waterton is from an original oil painting made by C. W. Peale in Philadelphia in 1824. An engraving of it forms the frontispiece of the third volume of the Essays on Natural History. The bust and the portrait correspond well when allowance is made for the forty years' difference in the age of the subject.

Dr. Franz Stuhlman, who accompanied Emin Pasha into the heart of Africa, saw much of the people called Pygmies. He looks upon them as the remnant of a primeval race which at one time occupied the

whole of tropical Africa and southern Asia. They have lost their original language, and have been encroached upon by surrounding tribes, even within the dense forests to which they retired, until they are met with only in scattered remnants. No trace of degeneracy is to be found among them, for, according to the accounts, they are well proportioned "and certainly not rachitic."

Evidence is adduced in Nature, by J. Howard Mummery, contradictory of the hypothesis that caries of the teeth is a modern disease and confined to civilized races. The author's father, in a communication to the Odontological Society in 1870, brought together the results of an inquiry extending over more than ten years, in which he examined more than two thousand skulls, and was brought to very different conclusions. Among thirty-six Egyptian skulls, caries was found in fifteen (41·66 per cent); among seventy-six Anglo-Saxon, twelve (15·78 per cent); among one hundred and forty-three skulls of Romano-Britons, forty-one (28·67 per cent); and among forty-four miscellaneous skulls of ancient Britons, 20·45 per cent, showed carious teeth. Of modern savage races, among the Tasmanians, 27·7 per cent, of caries was found; among native Australians, 20·45 per cent; among East African skulls, 24·24 per cent; and among the skulls of West African natives, 27·96 per cent.

Books are protected in India against the attacks of insects by pouring a few teaspoonfuls of refined mineral naphtha, or benzine collas, into the crevices of the binding, and then shutting up the volume in a close-fitting box. They have to be afterward sprayed over lightly with the finest kerosene oil, which should be rubbed off before it penetrates the binding. Another way is to brush the books over with a saturated solution of corrosive sublimate. In the Indian Museum Library the books are kept in close-fitting glass cases with a few ounces of naphthaline upon each shelf. The paste used in binding these books is also poisoned with sulphate of copper.

In the Kelvingrove Museum, Glasgow, is a crow's nest from Rangoon made of iron wire, such as is used in fastening the corks of aërated water bottles. Mr. Campbell, of the museum, quotes from the donor of the curiosity, who says that such nests can always be obtained from high trees in the vicinity of the factories of aërated water.

An extensive series of minute chipped stone implements from India, which has lately come into the possession of the United States National Museum, is described by Curator Thomas Wilson as comprising every condition of the implement and having the single peculiarity, in which these differ from other prehistoric implements, of remarkably small size. The cores are rarely more than an inch and three quarters in length, and the blades are rarely more than an inch and a quarter or an inch and a half, the majority of them being not more than an inch, while the finished specimen is frequently not more than five eighths of an inch in length. The finished implements are of various forms—slim, almost needlelike, triangular, with a base convex, straight, or concave, quadrilateral, trapezoid, rhomboidal, while the most delicate and finely finished are in the form of a crescent.

In their woodcut engraving, according to Mr. T. Tokuno, of the United States National Museum, the Japanese artists strive to imitate the original, even to the sweep of the brush, so closely that it shall be difficult for an inexperienced person to detect the difference, and they have been wonderfully successful. The methods employed by them are those used in Europe in the fifteenth, sixteenth, and seventeenth centuries. The material is wood cut in the direction of the fiber, or planks, for which since Bewick's time blocks cut across the fiber have been substituted with us.

The chief features of the Karst (limestone) regions of eastern Europe, according to Dr. Jovan Cirjic, are those known as *karren dolinen*, blind valleys, and *poljen*. The *karren* are surfaces composed of blocks of limestone separated by narrow fissures. The *dolinen*, called by English writers swallow holes, sink holes, or cockpits, are rounded hollows varying from thirty to more than three thousand feet in diameter and from six feet to three hundred and thirty feet in depth, and great numbers of them often occur in a limited space. They may be dish, funnel, or well shaped, or of other forms. Besides the simple basins, the *dolinen* also occur in the form of chimneys communicating below with blind cavities or with underground river courses or systems of fissures. The first are known in France as *avens*, and the second in Jamaica as *light holes*.

In the Mining School at Houghton, which had one hundred and one pupils in 1893, Michigan claims to possess the largest school of mining engineering in the United States. The school also excels in the number of graduates in proportion to its age. Its pupils are mostly farmers' sons, and twenty-three States and foreign countries are represented among them. Its equipment has been planned with the idea of providing the means for each student to occupy his entire time without obliging him to wait, and of making the laboratory take the place, to a large extent, of instructors. Candidates for admission are expected to be proficient in the use of the English language and in the special subjects required, including the solution of practical problems in mathematics. A three years' course is prescribed.

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